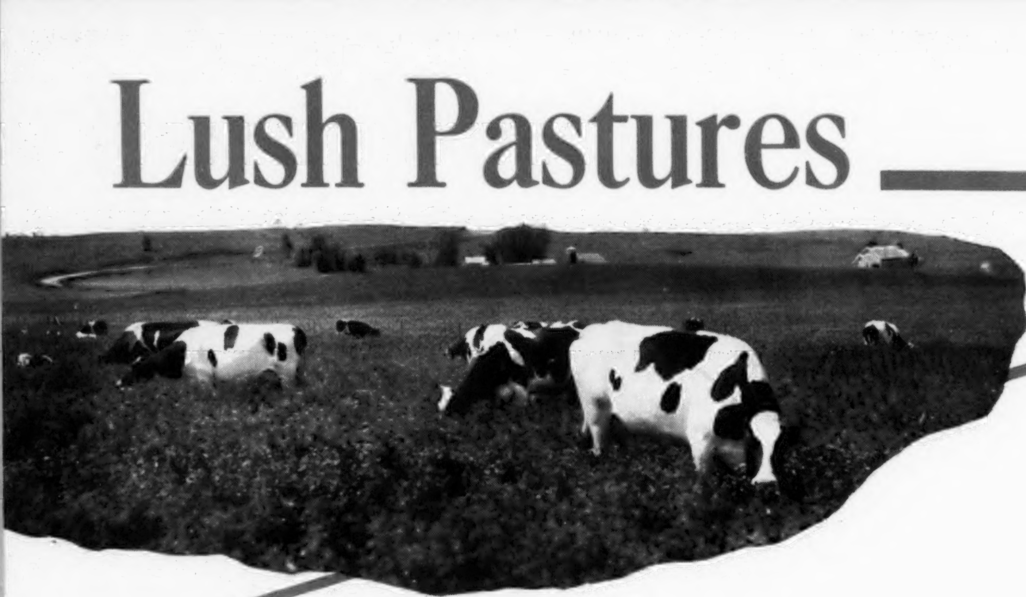
AGRICULTURAL ENGINEERING

NOVEMBER • 1946

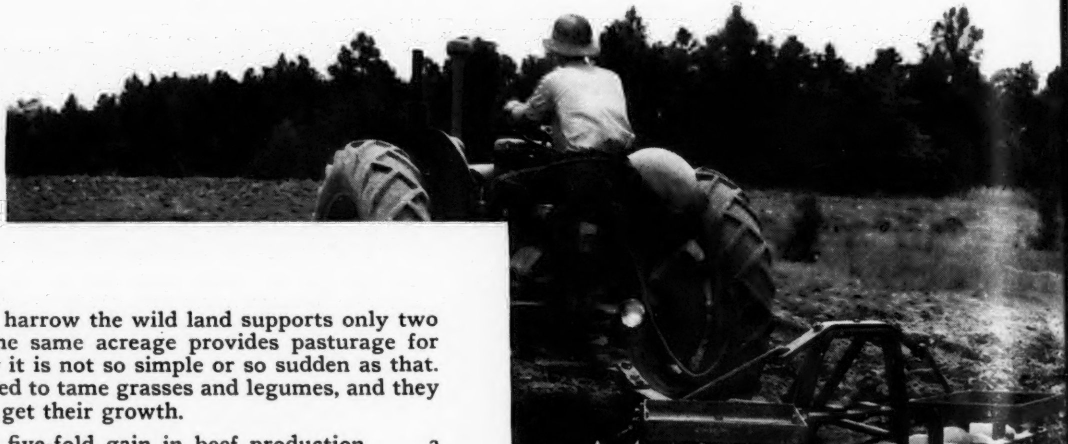
A.S.A.E. Fall Meeting • Chicago, Ill., December 16-20, 1946

THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

Lush Pastures



from Lazy Acres



Ahead of this harrow the wild land supports only two steers. Behind it the same acreage provides pasturage for ten steers. Actually it is not so simple or so sudden as that. The soil is also seeded to tame grasses and legumes, and they take a year or so to get their growth.

Just the same, this five-fold gain in beef production . . . a typical experience reported by a Florida cattleman . . . does depend on the Case Brushland Harrow. Because it "tills the untillable" it conquers land held captive by palmettoes, scrub growth and giant weeds. In other regions it masters land too rough to plow, too sticky for a plow to scour, or too rugged with small stumps and big stones.

The huge heat-treated disks roll over buried rocks, hold their shape and sharpness to slice through stumps and saplings. Powered by the swift pull of a Case "LA" tractor, the Brushland Harrow enables one man to conquer or recapture a dozen acres a day. Built with the extra strength and ENDURANCE which are the earmarks of Case machines, it makes a sound investment for the farmer who buys it and the bank that may finance it.

Obviously, the Brushland Harrow lends itself to operations for working organic matter into soil, for resisting wind erosion, and for enhancing soil capacity to receive and retain moisture. Thus it promotes soil conservation practice while adding to the productivity of land. It does both while multiplying productivity per man-hour—increasingly the dominant factor in farm costs and earnings. Building machines to increase man-capacity is this Company's contribution to all the advanced farm practices. J. I. Case Co., Racine, Wis.

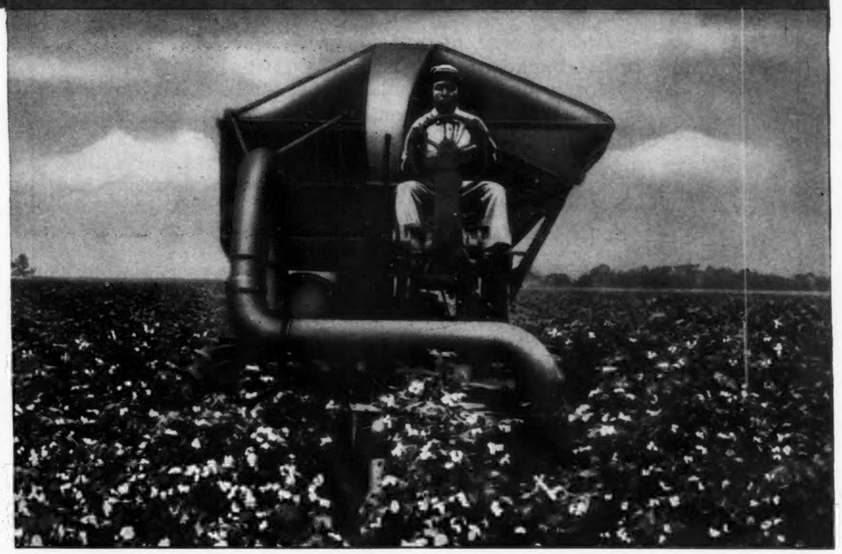
CASE

SERVING AGRICULTURE SINCE 1842

IT'S A MATTER OF *principle...*

Secret of this cotton picker's operation is a picking unit operating on the principle of "spindles and doffers." The barbed spindles (1) literally stick their "fingers" into the cotton plant as it passes through the machine and then withdraw the lint without "raking" the plant or harming the unopened bolls. Doffers (2), rotating discs with rubber projections, remove the lint from the spindles, after which it is conveyed by a fan (3) and blown against cleaning grates in the top of the basket.

More power for dependable picking is always available with gasoline in high compression engines because of this principle: Each additional pound per square inch of compression pressure before ignition gives approximately *four* additional pounds per square inch of pressure on the power stroke after ignition. As a result, high compression tractors mean more power plus all the advantages of clean, dependable gasoline operation.



Sound principles pay off on the farm

Many cotton growers are about to revolutionize their operations with mechanical pickers and flame cultivation for cotton. Already popular in the south as well as throughout the country are high compression gasoline tractors—preferred by many farmers because their dependable, easy operation on a single fuel eliminates many problems with unskilled help.

This is just another reason why *farmers today buy more high compression tractors than any other type.*

***As a matter of principle*– RECOMMEND HIGH COMPRESSION TRACTORS**

ETHYL CORPORATION, *Agricultural Division,* Chrysler Building, New York 17, N. Y.
Manufacturer of antiknock fluid used by oil companies to improve gasoline.

AGRICULTURAL ENGINEERING

Established 1920

CONTENTS FOR NOVEMBER 1946

Vol. 27, No. 11

This Journal is owned, edited, and published monthly by the American Society of Agricultural Engineers.

Editorial and advertising departments at the executive office of the Society, Saint Joseph, Michigan. Publication office at Benton Harbor, Michigan.

SUBSCRIPTION PRICE: $3.00 a year, plus an extra postage charge to all countries to which the second-class postage rate does not apply; to A.S.A.E. members anywhere, $2.00 a year. Single copies (current), 30 cents each.

POST OFFICE ENTRY: Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921.

EDITORIAL

Engineering in Farm Safety

DURING the recent safety session of the National Safety Congress it appeared that the opportunity for agricultural engineers to help a large number of farm people go on living, and with their normal number of hands, feet, eyes, etc., has not been fully realized by many agricultural engineers, or their employers.

It is true that interest is increasing, thanks to the farm division of the National Safety Council and its many cooperators, including the A.S.A.E. Committee on Farm Safety. A small but growing number of agricultural engineers and others are being enabled to devote their full time to farm safety work, particularly in extension work, to increase farm adoption of known safe practices and avoidance of common hazards. Others are giving it more than incidental attention in design, development, and recommendations to farmers.

But these extension people are beginning to run into cases where their work is hampered by lack of specific technical engineering data. The common-sense range of safe procedures is limited by the extent of common knowledge. It can be increased only by new knowledge of the factors influencing safety in new situations, in new types of farm work, with new structures and equipment.

Discussion got around to the question of job instruction, and C. L. Hamilton emphasized the point that, to a large extent, farm safety involves the question of the right way to do a specific job.

Much of the information we have along this line is alright as far as it goes, but it doesn't go far enough. And some of it doesn't involve much engineering, but to develop it further will require a lot of engineering.

There isn't much technical engineering involved in telling a farmer the safe and unsafe places for a pitchfork, or how to set up a ladder.

But there is plenty of technical engineering, as much as anyone could want, in determining the right way to do a lot of farm jobs with the newer, larger, more powerful, more complex equipment, structures, and operations involved in farming.

The right way to do these jobs starts with sound, safe design of the equipment used, and extends through use practices, to the point where the dangerously depreciated or obsolete tool, machine, or structure is safely disposed of and replaced.

Who but an engineer can calculate the strength of materials, the static and live loads, the momentum, stability, balance, anchorage; the critical speeds and turning rates; the alertness of eye, ear, smell, touch, and judgment needed for safe operation of a specific machine; the reaction time, agility, and force needed to actuate controls within the limits of safety; the proper emergency action to prevent accidents; the locations, types, and mechanics of safeguards, controls, warnings, and emergency equipment which might be provided with reasonable economy; the nature and hazards of depreciation; and the hundred and one other narrow physical barriers between safety and tragedy?

Who but an agricultural engineer will analyze these factors as they apply in farming and interpret them into right, safe-operating equipment and practices?

This is agricultural engineering with human lives, as well as dollars, in the balance. It is public safety engineering to reduce the farm work cost of 4500 lives per year, and a reasonable prospect of saving many of them, not by dramatic rescues but by patient, intensive, driving, relentless and continued research, design, and teaching — exhausting every opportunity to minimize not only the human error but the danger associated with human error in farm life and work.

Agricultural engineering objectives of high farm productivity and material welfare can be advanced, and their defeat in thousands of individual cases by needless death and injury can be avoided, by agricultural engineering attention to the engineering aspects of farm safety. Safety is more than a field of specialization for a few agricultural engineers. It is an opportunity, an obligation, a consideration in the daily work of all agricultural engineers. To do our jobs in the right way we need to make the most of every opportunity to help farmers do their hundreds of specific jobs in the right and safe ways.

Correcting a Misunderstanding

ONE misconception of the agricultural engineering field repeatedly turns up to plague and mislead a few of our brother engineers in other fields, and some of their employers.

It is the idea that engineering principles and techniques outweigh agricultural objectives in providing the structural, mechanical, electrical, hydraulic, and other means of improving farm operating efficiency and living conditions. It is the idea that agricultural production equipment can be engineered from the manufacturer's drafting room, by the same men who develop products for urban industries and consumers.

It leads, at best, to these individuals learning the hard way about the intricacies of functional design in engineering for agricultural uses.

It can be corrected by several measures.

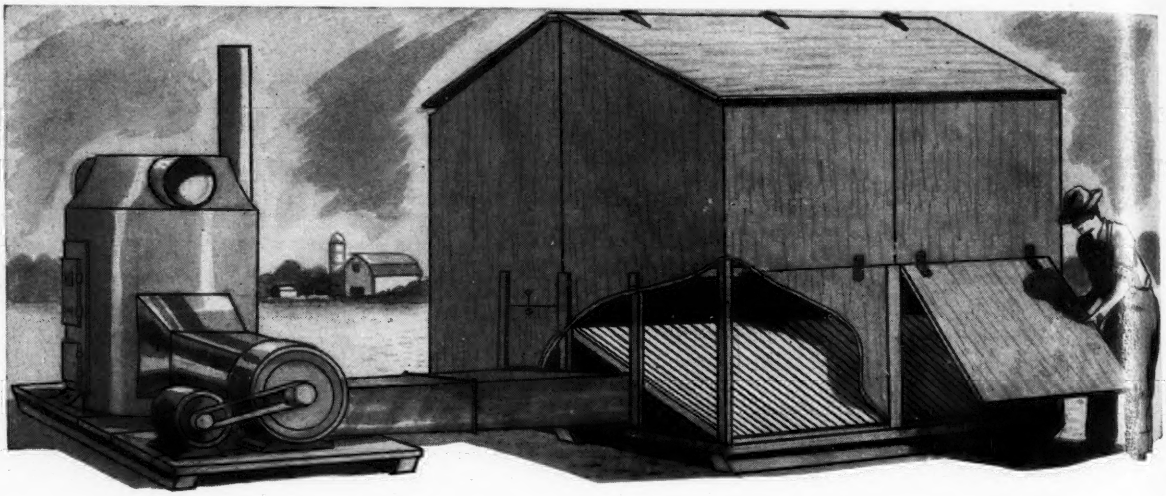
One is a reminder to the engineers and employers concerned that the principles and techniques of engineering are not universal tools. To be used to advantage, the ones which fit must be applied in the proper manner to the nub of an individual, specific problem. In agricultural engineering, agriculture provides the problems. It provides the situations to which engineering tools must be fitted. It involves a wider range of complex combinations of variables than is found in most other fields of engineering application.

A wide, intensive knowledge of and association with both agriculture and engineering, combined in the same individuals, is needed to define agricultural problems and opportunities in engineering terms. And the required knowledge of agriculture is not farming as seen by the Sunday driver or the pastoral artist. It is not the agriculture recalled from having grown up on or visited farms 40, 20, or even 10 years ago.

It is agriculture as practiced by the various types and abilities of farmers of today, plus individual factors as known to agricultural scientists—the chemistry and microstructure of soils; the characteristics of crop plants, livestock, and pests; the sciences of plant, animal, and human nutrition, to name only a few.

Another corrective measure is to clarify for interested engineers in other fields the several ways in which they can be of service to agriculture without attempting to learn enough about agriculture to qualify as agricultural engineers.

They can contribute to engineering progress in their respective fields with a reasonable *(Continued on page 508)*



Movable Two-Bin Seed Corn Drier Built of Exterior Type Douglas Fir Plywood

The ability of Douglas fir plywood to take a tough assignment and do it well is illustrated in this ear corn drier—MID-WEST plan No. 75501.

A batch drier such as this is subjected to relatively rapid cycles of high humidity at air temperature and dry, high-temperature air from the furnace. In addition, it must withstand the vicissitudes of weathering, racking stresses incident to moving, and impact and loading stresses from the grain.

The enclosing material must remain tight under these conditions if the unit is to retain its efficiency and prove durable. Fir plywood, properly used, will do the job.

The large sturdy panels resist mechanical stresses. They maintain dimensional stability against moisture change, and the minimum joint footage permits an insignificant air leakage. Removing the sloping floor grids permits the plywood floor to be swept clean to prevent harboring insect infestation. The method of framing, with tight-fitting doors and all panel edges supported against framing members, practically prohibits rodents entering by gnawing their way through floor or walls.

Only the EXTERIOR type of Douglas fir plywood is recommended for structures such as this where moisture is anticipated. Painting the interior faces of the outer walls and the underside of the roof will help prevent moisture blisters and early deterioration of the exterior paint coating.

The bin may be blocked up high enough to permit the dump doors to discharge into an elevator boot or conveyor. The roof and gable ends may be omitted if the bin is to be placed permanently inside a larger building.

Brief Specifications

FRAMING

Skids 4" x 4". All other framing 2" x 4". Floor joists, studs and rafters spaced 2'0" on centers.

FLOOR

Flooring ⅜" EXTERIOR Douglas fir plywood laid across joists and nailed to them and headers with 6d galvanized nails spaced 4"o.c. Removable grid floor panels of 1" x 4" spaced 1" apart must be accurately made to wedge in place between sill and partition.

WALLS

Sheathing ¼" EXTERIOR Douglas fir plywood laid horizontally across and inside of studding and nailed at all bearings with 6d galvanized nails spaced 4" o.c. Gluing plywood to frame with cold-setting phenol or resorcinol type adhesive before nailing will make a tighter and more rigid structure.

ROOF

Roofing panels of ⅜" EXTERIOR Douglas fir plywood hinged at ridge to form "lift-up" doors. Continuous 2" x 2" run-around frame and transverse stiffeners spaced 2' o.c. on underside will prevent warping.

PAINTING

Two or three coats of good quality exterior paint. Roof similarly painted or coated with asphalt mastic. Painting inside of walls and underside of roof will help prevent water blisters forming beneath outside paint.

DOUGLAS FIR PLYWOOD
LARGE, LIGHT, STRONG,
Real Wood
PANELS

DOUGLAS FIR PLYWOOD ASSOCIATION

Tacoma 2, Washington

AGRICULTURAL ENGINEERING

VOL. 27 NOVEMBER, 1946 No. 11

A 5-Year Summary of Dairy Barn Research

By S. A. Witzel and Dr. E. E. Heizer

MEMBER A.S.A.E.

PROMPTED by the seemingly great need for improvements in dairy cattle housing, and encouraged by the many requests from dairy farmers for help in solving their dairy cattle housing problems, the authors began having noon-hour discussions on the subject late in 1938. The program of dairy cattle breeding had progressed until it included herd testing, proven sires and artificial insemination. The next step in better breeding would follow if the best cows could be kept going for a longer period of time so that there would be more calves from these good cows. The life of a cow in production was only 2½ to 4 years. With beef prices at low levels this short productive period often reduced profits.

The use of labor on the dairy farm needed study. About 150 man-hours per cow per year were required. If the efficiency of chore labor could be increased proportionately to that of growing corn, for instance, the time could be reduced to about 30 man-hours per cow. The dairy chore is hard work easily done by strong persons in good health. It is, however, a steady job, and when a person is ill, or when a young boy or girl or an older person or a housewife must "pinch hit", it's just too much. Tractors with lights and a starter are not too difficult for the farm housewife or daughter to operate in emergencies, and you just can't keep young boys off of them. The question then was "How can the chores on the dairy farm be streamlined?"

Frequent losses of dairy barns, feed, and sometimes the herd by fire or windstorm created a demand for something more permanent and firesafe. True it was that the insurance on cows, feed and barn helped, but all too often the milk check vanished for from six months to two years, and that wasn't insured. Little then did anyone realize that the day would come when building materials could not be had for new barns, and that new barns would often cost more than one paid for a whole farm. It was acknowledged, however, that barn costs were running high and thus one of the aims of the research project reported in this paper has been to lower barn costs. The development of site-welding of steel frames for farm buildings promises to do much to help keep costs down.

Quality of milk had been under continuous improvement for many years. Anything that was done in the line of barn improvement should preserve and improve milk quality. In other words, there was need for herd management techniques and improved design and equipment that would make the production of good quality milk easier.

Feed efficiency has always been a problem of major interest to every dairyman. New methods of harvesting and preserving both dry and green roughages all pointed to new opportunities in barn design. Likewise production and herd health, including the gain of calves and young stock, needed to be studied and improved if possible. This angle has a very important bearing on the profits of the farm.

Most farms need all the manure available, and it needs to be preserved or stored and used at a time when it will provide greatest benefit to the soil and crops. How best could this be done? Would manure packed and preserved in a loose-run barn and applied to the fields when the greatest benefits could be derived from it be more valuable than manure taken direct to the field from the stanchion barn? Would this manure pack breed flies?

Research data on dairy cattle housing was reviewed. The loose-housing barn and milking parlor seemed to offer a possible improvement. While the direct approach to bringing a cow into the laboratory and collecting data on her reactions to different environments was considered, a better starting place seemed to be the study of whole herds of dairy cattle under actual housing conditions. The latter plan would allow the stanchion and the loose-housing barns to be compared.

The opportunity to proceed with the Wisconsin dairy barn research project came when the Carnegie-Illinois Steel Corporation offered to establish a scholarship for the purpose of carrying on this research work.

In the earlier report ("Dairy Cow Housing Under Study", by Witzel and Barrett, AGRICULTURAL ENGINEERING for March, 1944) it was stated that the project started out as a comparison between the conventional stanchion barn designated as barn A and the non-insulated, loose-housing or pen barn known as barn C. One herd of 17 cows designated as herd A was housed in the warm stanchion barn A, while another herd of 17 cows referred to as herd C was housed in the cold pen barn C. Here are two variables, cold and warm housing and loose stabling versus the stanchion barn. To separate these variables a third barn B and herd B were added at the end of the third year. Barn B was an insulated pen barn first occupied in January, 1945. The delay caused by the construction work of building this addition to the barn made this test season short. This additional herd B housed in a warm loose-housing or pen barn arrangement would make possible comparisons between

Fig. 1 An air view of the physical plant in which the Wisconsin dairy barn research project is being conducted

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at St. Louis, Missouri, June, 1946, as a contribution of the Farm Structures Division.

S. A. WITZEL is professor of agricultural engineering and E. E. HEIZER is chairman, dairy husbandry department, University of Wisconsin.

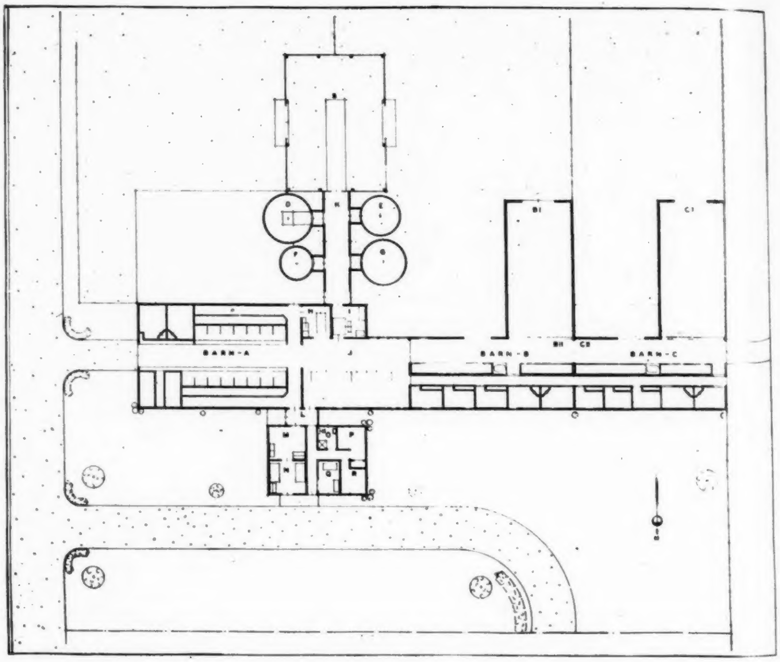


Fig. 2 Ground plan of the Wisconsin dairy barn research project: A, barn A, a conventional stanchion barn; B, barn B, an insulated loose-run barn; B1, loafing area; B11, paved feeding area; C, barn C, a non-insulated loose-run barn operated with a door open at all times; D, chopped hay storage; E, prefabricated galvanized sheet iron silo; F, ever-normal grain bin rebuilt for ground feed storage; G, site-welded black sheet iron silo; H, hospital room; I, scale and milking machine room; J, eight-stall milking parlor; K, covered passage; L, covered passage; M, washroom for milk utensils; N, cooling room for milk; O, toilet and bathroom; P, student room; Q, furnace room; R, office; S, baled hay and bedding storage.

housing in stanchions and loose stabling without the effect of temperature difference. Likewise the cold pen barn C could be compared with the warm pen barn B without the effect of stanchioning and loose-stabling factors.

Supervision and Operation. The project has been under the joint direction of Dr. E. E. Heizer of the dairy husbandry department and S. A. Witzel of the agricultural engineering department of the University of Wisconsin. In the scholarship arrangement with the University, the Carnegie-Illinois Steel Corporation set up a fund for a research assistant. They also furnished and erected the steel buildings and furnished a part of the equipment. The dairy husbandry department furnished a good herd of Holstein cows, feed, barn labor, and assigned a herdsman to the project. In addition to the regular dairy barn chores, their staff helped weigh the cows, weighed and sampled the milk, weighed the feed, kept barn lots clean, hauled manure daily, assisted with the cleaning of the bedded area in B and C, and took care of feeds, milking, feeding, etc.

The agricultural engineering department's work included cooperation with the Carnegie-Illinois Steel Corporation in the design, erection, and maintenance of the physical plant. Collection of weather data, barn temperature and humidity data, animal weights, manure temperature data, and time study data were all a part of the engineering assignment. The student on the fellowship, when it has been filled, helped with the various maintenance and construction jobs, assisted in taking visitors through the barn, counseled on various management and operational problems, collected and assembled data, and made up various charts. Money saved during the war when the fellowship could not be filled has now been used to purchase a manure spreader with fluid-tight bottom and tractor so the manure problem at the barn can be given proper study next year.

Test Periods. The research work has been carried out for five winter periods, four of which were for six months and one of which ran for nine weeks. The actual test period dates, length of test period, and barns in operation are as follows:

Period No.	Dates	No. of days	Barns in Operation
1	October 1, 1941 to March 31, 1942	183	A & C
2	October 12, 1942 to April 11, 1943	183	A & C
3	October 12, 1942 to April 12, 1944	184	A & C
4	January 31, 1945 to April 13, 1945	62	A, B & C
5	November 14, 1945 to May 1, 1946	168	A, B & C

Three Barns. From the first the aim has been to have only high-producing cows in the herds used in this dairy barn research project. In the beginning some of the young cows had been milking a year before and there were records on their production to go by in dividing the herd. Other animals were heifers recently fresh or still to freshen. The cows with some production record were divided between herds A and C on the basis of weight, freshening dates, and production. The heifers were selected at random except that weights and freshening dates were considered.

For two years the herds were kept in the same barn and the third year they were changed. Since herd A was in barn C the third year, and high all three years, it indicated a little better producing capacity in that herd.

Due to the late start on the 1944-45 test period, and also due to the fact that it did not seem advisable to move some of the best cows into the cold barn in the middle of the winter, the division of the herds was not made to give balance in productive capacity. Several heifers were used in herd C to fill in. Nevertheless it was decided to run a short test period in order to get everything organized for the 1945-46 test period.

At the beginning of the fifth year the herds were completely reallotted after being divided into groups of uniform characteristics, and selection was made at random from each of these groups for all three herds A, B, and C. At this time a greater percentage of the animals had records. In the summer the three herds, A, B, and C, were all handled as a single herd and milked in the milking parlor. Less time is required for summer milking by using the milking parlor rather than the stanchion barn A.

While it is not known how evenly the two herds had been divided for production capacity, it is probable that the division was quite fair and uniform. This factor is one of the reasons, in a test of this kind involving entire herds of cattle, and in addition working with weather as a factor, that the test periods should be duplicated several times. In order to speed up the development of a background of experience with loose-run barns, several cooperating farmers have been assisted in the development of this system of

housing for dairy cattle on their farms. Designs have been prepared and operating techniques specified which would insure the production of quality milk. In practically all of these experiences the loose-housing system has proven to be satisfactory.

Weather and Barn Temperatures. The weather observations made at the project were incorporated with that from the two official Madison weather stations located at North Hall and at Truax Field. One of the accompanying charts (Fig. 3) shows the accumulated degree days of heating load where the inside temperature is 50 F (degrees Fahrenheit). All of the winters have been near normal, but in the 1943-44 period there were 4307 degree-days of heating and in 1941-42 there were only 3249 degree-days of heating. The average for the five-year period was 3710 degree-days.

The percentage of possible sunshine has been charted (Fig. 4) on an accumulative basis for each of the test periods. It is interesting to note that the period with the greatest heating load (1943-44) had the most sunshine, and the season with the lightest heating load had the least sunshine. Thus the cows may benefit more from solar radiation in a cold winter than in a mild winter.

The precipitation for each of the five years is charted (Fig. 5) on an accumulative basis. Likewise wind velocity (accumulated monthly average in miles per hour) is charted (Fig. 6). Humidity records are available, but have not been included in this report. A chart (Fig. 7) of average monthly temperatures is included.

In general the weather during the test periods has followed a general average pattern with normal fluctuations as might be expected. There have been some severe fluctuations in temperature each winter. Normal winds, snow, and sunshine prevailed within moderate limits.

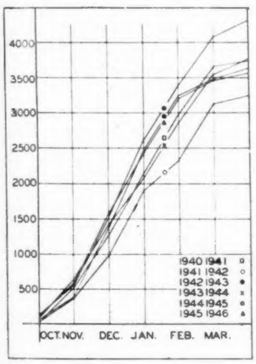


Fig. 3 Accumulated degree days

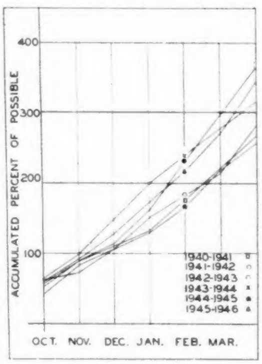


Fig. 4 Percentage of possible sunshine

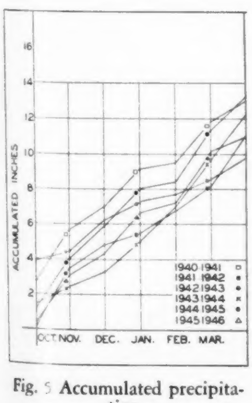


Fig. 5 Accumulated precipitation

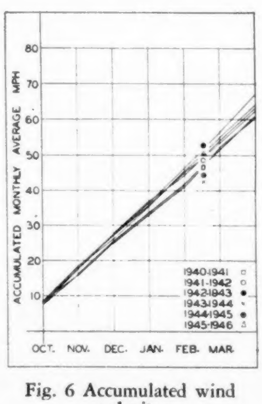


Fig. 6 Accumulated wind velocity

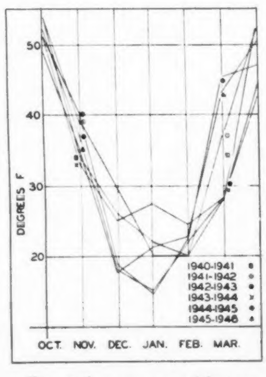


Fig. 7 Average monthly temperatures

Temperature and Humidity. Continuous records have been maintained throughout the test period with recording hygrothermographs located in each barn and one out of doors. A typical graph of average mean barn temperature (Fig. 8) and outside temperature records for the test period 1945-46 is included.

For some time no relationship between outside temperature and production could be found. Comparisons on a daily basis seemed to be hopeless. However, data from the 1945-46 test period when graphed on a weekly average basis produces a trend that may lead to some helpful conclusions. It will be noted that both the warm barn herds seemed to be affected by outside temperature while the cold barn herd seems to have a more nearly constant production.

Another temperature comparison which seems to follow a definite curve is that of outside temperature and inside temperature for each barn. In other words, the temperature relationships seem to be different for each barn.

The humidity records do not seem to lend themselves to graphic representation. However, it can be said that barn A was effectively ventilated with the electric fan in cold weather and with windows in mild weather. This barn has 6 in of mineral wool insulation over the ceiling and the sidewalls are lined inside and out with galvanized sheet metal. A 25/32-in fiber insulation board completes the wall. The wall on the north side condenses a little moisture when outside temperatures fall to 0 F or below.

Barn B is insulated the same as barn A, but has more exposed wall area per animal unit because of the L shape of the building. It also has the manure pack which gives off heat as well as moisture. Electric fan ventilation maintained a lower humidity than in barn A, while the temperature in barn B averaged 3 deg lower than in barn A. The bedding in B seemed to soften up and become damp quicker than in barn C. Some odors could be detected in this barn, perhaps from the manure pack.

Barn C had fresh dry bedding in the bedded area throughout the test periods. Since an outside door was open all of the time, and the roof ventilators also were open, there was ample air movement and no objectional odors could be detected. The bedded area in barn C was easier to keep clean, and required less bedding than for B. This was also due in part to the fact that parts of herd C were out of doors most of the daytime, while herd B was confined to the barn the same as herd A. Therefore, more trampling of bedding took place in barn B.

Labor Comparisons. The comparative labor requirements were determined by time-study methods with one observer per laborer. The time, taken by a stop watch, was recorded to the nearest second. These data were then tabulated to determine the total time required for each operation. A final check out on total time against lapsed time and a grouping of related operations completed the study. At first this information was used as a basis for improvements and adjustments. Later this type of data was used for labor comparison between barns.

Spot time studies were made during the first winter to help iron out management and equip-

ment problems and to assure the utilization of all facilities to best advantage. The next year similar time studies were made to help locate bottlenecks in the dairy cattle housing systems including the milking room. It was agreed, for instance, that there should be eight stalls in the milking room instead of four. In this way two men could follow fast-milking techniques and still give the cows enough time to eat their concentrates. Likewise it was soon found that a redesign of the milking stalls and feed mangers in the milking room would be necessary.

Alternate milking stalls were increased from 3 ft in width to 3 ft 9 in for more room in milking. Larger feed mangers were needed to reduce waste of concentrates being fed in the milking room. Improvements were fairly well worked out and completed when the new addition to the barn and the third herd were added to the project. As soon as everything seemed to be working smoothly after the adjustments were made and adequate help became available the time studies were made for barn labor comparisons.

During the 1944-45 period a two-day time study was taken, and during the 1945-46 period an eleven-day time study was taken. From these two tests the comparative percentages which are shown in Table 1 were made. The total milking time was about 22 per cent shorter in the loose-barn milking parlor plan than in barn A. In barns B and C feeding time was 25.9 per cent less in B and 23.2 per cent less in C than in A. The time required for preparing and handling of bedding was 40.3 per cent less in B and C than in barn A. In the over-all labor picture, including manure removal from B and C by mechanical means, we have a 17 to 18 per cent saving of labor in barns B and C. However, the installation of a mechanical barn cleaner in A might well bring this percentage difference down to a much smaller figure. A more fair comparison of the two labor situations might be obtained from the figures where barns B and C were cleaned by hand labor. Here we find about an 8 per cent labor requirement difference in favor of the pen barns. Considering a mechanical cleaner in A, and the use of a mechanical loader in B and C, the comparison would probably run much the same as with hand labor.

Thus, from the average of these two time studies, we might well conclude that the pen barns with this type of layout require about 8 per cent less labor than the conventional standard stanchion barns. One should note, as the above figures indicate, that the percentage difference might well be altered in favor of either barn by the use of mechanical equipment in one barn and not in the other. Another factor which can easily sway the figures, at least to a mild degree, is the enthusiasm of the operator and its effect on the chore time in the particular barn he likes best.

TABLE 1. COMPARISON OF LABOR REQUIREMENTS FOR TWO YEARS

		Barn A	Barn B	Barn C
1	Average total time spent milking	1:51:17 100.0 per cent	1:27:58 78.0 per cent	1:26:57 78.0 per cent
2	Average total time spent preparing feed and feeding in each barn	55:52 100.0 per cent	41:31 74.1 per cent	43:8 76.8 per cent
3	Average time preparing and handling of bedding	33:47 100.0 per cent	19:42 59.7 per cent	19:37 59.7 per cent
4	Average total (not including manure removal in barns B and C)	6:16:24 100.0 per cent	5:7:28 81.6 per cent	5:03:47 80.6 per cent
5	Average total (including manure removal in barns B and C by mechanical loader)	6:16:24 100.0 per cent	5:10:00 82.8 per cent	5:06:19 81.8 per cent
6	Average total (including manure removal in barns B and C by hand labor)	6:16:24 100.0 per cent	5:47:28 92.2 per cent	5:46:19 91.2 per cent

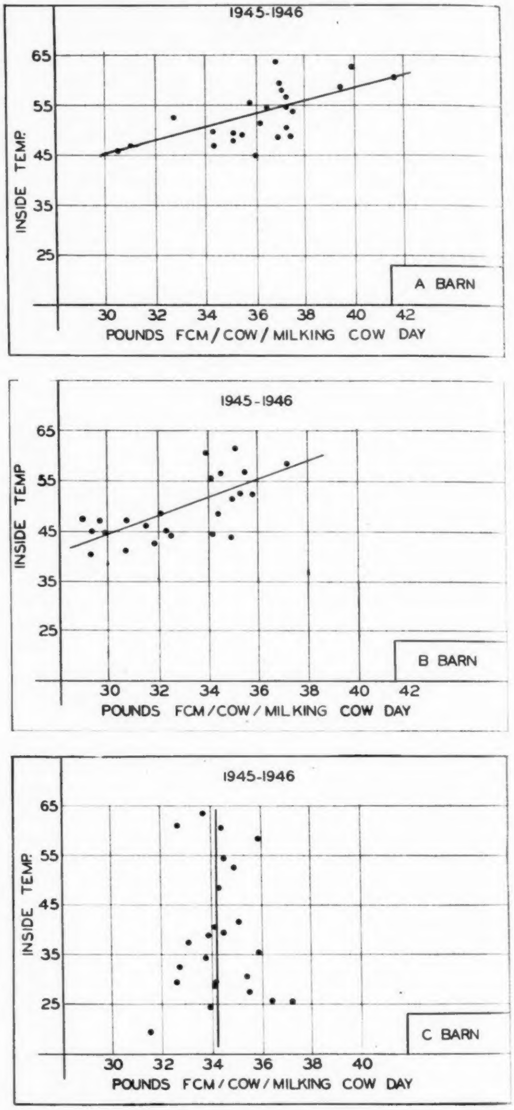


Fig. 8 Average daily mean inside temperatures for barns A, B, and C for periods of one week

Feed Comparisons. Feeds from the same supply were fed the herds throughout each season, and all feeds weighed and weights recorded as they were taken into the barns to be fed. The aim each season has been to feed all herds on a fairly uniform nutritional level and still not feed more than they would clean up. Due to shallow feed mangers in barn C the wastage of hay in the first three test periods ran up to as much as an estimated 10 per cent on some of the poorer lots of hay. The fifth period is therefore the one complete test period run after the feed manger was rebuilt and feed waste was practically eliminated.

Comparisons of feed consumption were made in pounds per cow per day and also in pounds of TDN (total digestible nutrients) per cow per day.

HAY: The herds were fed baled hay which fluctuated from top quality second and third cutting alfalfa to fair quality clover and mixed grasses. Everything possible has been done to secure roughage of uniform quality. The storage space being limited made necessary the purchase of baled hay at periodic intervals throughout each season. The variation in quality of hay had a marked effect on the quantity which the cows would eat. In the 5-year average, with herd A consuming hay on a 100 per cent base barn, herd B was fed 114 per cent and herd C was fed 112 per cent. It is important to consider the 1945-46 season or fifth test period here because the cows were uniformly divided and the feed mangers were operating without waste. Here then in the fifth year, with the consumption of hay by herd A on a given base of 100 per cent, herd B used 101 per cent and the herd C used 102 per cent.

SILAGE: Corn silage has been the main succulent feed used throughout the test periods. Some grass silage has been fed. Silage feeding has been quite moderate in amount ranging from 20 to 40 lb per cow per day. For the 5-year average, if the quantity of silage consumed by the herd in barn A is taken as 100 per cent, then herd B consumed 98 per cent and herd C consumed 108 per cent. For the fifth test period, if the base for herd A is taken as 100 per cent, B consumed 104 per cent and C, 111 per cent.

CONCENTRATES: Concentrates were fed to the cows individually, herd A being fed concentrates and roughages at the same time, while herds B and C were fed concentrates in the milking parlor while being milked. For the 5-year average, if the amount fed herd A equals 100 per cent, then herd B was fed 90 per cent and C, 97 per cent. For the fifth test period with herd A at 100 per cent, herd B was fed 98 per cent and C, 100 per cent.

TOTAL DAILY FEED AND TDN: In order to study the total feed intake, the total pounds fed to each of the herds and the total pounds of TDN fed to each herd has been charted. For the 5-year average, with A at 100 per cent, the TDN fed herd B was 104 per cent while herd C was fed 106 per cent. On the other hand, for the 5-year period with herd A at 100 per cent, herd B consumed in total pounds 102½ per cent and herd C consumed 107 per cent.

FEED COSTS: The roughage feeds were relished by the pen barn herds. This was especially true of herd C in cold weather. Because the pen barn cows, herds B and C, consumed more roughages and less concentrates than herd A, it actually cost less to feed them for the last two test periods 4 and 5. The following feed cost study is presented.

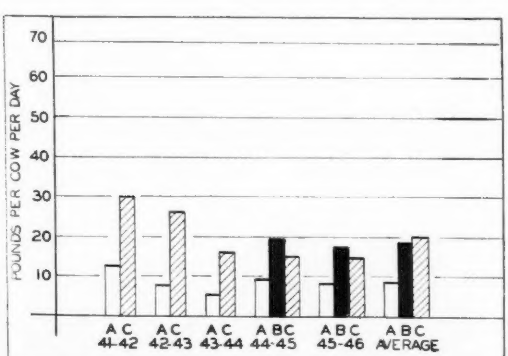


Fig. 9 This graph shows the bedding requirements

AVERAGE FEED CONSUMED AND COST OF FEED FOR THE 1944-45 AND 1945-46 PERIODS

VALUES ASSIGNED:

Concentrates at $60.00 per ton
Hay at 20.00 per ton
Silage at ⅓ the cost of hay

	Herd A Pounds per cow 1 day	Herd A Cost	Herd C Pounds per cow 1 day	Herd C Cost
Silage	24.48	$0.0816	26.42	$0.0881
Hay	24.22	.2422	26.07	.2607
Concentrates	11.00	.3300	9.26	.2778
Total	59.70	.6538	61.75	.6266
Per cent	100	100	103.5	95.8
TDN (total digestible nutrients)	24.81	.6538	24.80	.6266
Cost 1 lb TDN		.0264		.0253

Bedding. Baled oat straw bedding has been used in all barns throughout the test periods except for an occasional emergency when the supply was temporarily depleted. Baled shavings or poor quality hay was used during these short intervals. In Fig. 9 showing the bedding requirements it will be noted that during the 1941-42 period the loose-housing barn C required 34 lb of straw per day per cow while barn A required 10 lb. In this first test period barn C was operated with the area along the feed mangers bedded. The loafing area was well bedded and clean, when bedded once each day. However, the area along the feed mangers required bedding twice daily, and even then it was always punched up and dirty so that the cows tracked manure into the milking parlor and their feet were covered with manure almost to their knees. When a cow would lie down in this area, she required a washing to clean her up. This also placed a manure pack right up to the milking parlor door. It just seemed like larger cows in heavy production eating a lot of succulent feed could dirty up the feeding area regardless of how much bedding was added.

It was decided to pave the feeding area along the feed manger and clean daily. This would remove the bedded area some distance from the milking room and make a clean feeding area that could be quickly scraped and cleaned daily. The cleanliness of the cows improved, and since this proved to be a good place for cows to stand, it saved a lot of trampling of the bedded area. As a result of this change the bedding requirement should have been much less in barn C for the second period. However, at this time every effort was being made to develop operating techniques which would protect the quality of milk. It was obvious that bedding was wasted as it was not all worked down into manure. It is interesting to note the effect of gutter drains on the bedding required for barn A. These drains were installed the summer following the first test period.

In the 1943-44 period straw had become expensive and it was decided to keep bedding requirements as low as possible. By careful use of straw bedding barn A was operated on 4½ lb per cow per day, while C was operated on 13 lb per day. The cows were clean and the quality of milk was maintained. For the 5th year, 1945-46, if herd A is taken as a 100 per cent base, herd B required 249 per cent and C required 229 per cent.

Milk Production. The cows have been milked twice daily during the test periods, the milk being weighed from each cow and recorded. The first three test periods the milk was tested by an official tester once a month. The last two test periods milk samples were taken each milking to make up a weekly composite sample for each cow. The latter should be more accurate although the butterfat test percentages do not fluctuate seriously.

The basis selected for production comparisons is the Gaines uniform energy formula for fat corrected milk. FCM (4 per cent fat corrected milk) $= 0.4 \times$ pounds of milk $+ 15 \times$ fat. This seemed to be the fairest measure of actual production for comparison purposes.

The basis for comparison of herd production used herein is the FCM per cow per day. The FCM per cow per day is shown in Fig. 10 for each of the test periods with the average for test periods 1, 2, 3 and 5. Test period 4 had several heifers added to fill in because there were not enough cows used to cold housing at the time the test started the last of January. On the basis of this 4-year average, if herd A is used as a 100 per cent base, then B produced 100.5 per cent while C produced 97.3 per cent. On the basis of the 1945-46 test period when the cows were divided entirely by chance and perhaps more uniformly than for the other test periods, herd A produced 100 per cent, B produced 95 per cent and C 100 per cent.

Quality of Milk. The quality of milk that has been produced by each barn has been under spot testing for bacteria counts from the beginning of the project. Good quality of milk was produced during the first test period. Bacteria counts were higher in barn C due largely to the fact that the cows were dirty. After the feeding area along the feed manger was paved in barn C the bacteria counts on the milk were lower and more uniform. Bacteria counts averaged 5,515 for barn A and 18,520 for barn C. This improvement continued with minor adjustments in operating technique until in the third test period barn A had an average of 8,911 bacteria count and C had 6,783. No extra grooming, clipping or cleaning was done in either barn. Fast milking technique was in use. In order of milking, barn A was milked first and no sterilizing of utensils occurred between barns A and C in this third test period.

The order of placing cans in the cooling tanks was found to affect the bacteria count. In other words, the first cans (barn A) placed in the tank cooled more rapidly than the last cans (barn C) placed in the tank. More thorough cleaning of the milk cans also helped reduce the bacteria count throughout all barns. The bacteria count for the last part of the fifth period was A, 4,746; B, 5,320; C, 7,445. The bacteria count average of the annual logarithmic averages was A, 7,058; B, 10,570, and C, 11,485.

Herd Health: Cows. Herd health was one of the major factors in getting the dairy barn research project started. While it has not as yet been possible to compare the same herds in the same barns over a period of years, it was considered important that complete health records be maintained. In this way some definite conclusions might be made.

The summary of herd health is given in the following 5-year summary:

	Herd A (5-year) Total	Herd B (1-year) Total	Herd C (5-year) Total
Stiffness	2	0	0
Lame	2	0	1
Knees and hocks	4	0	0
Foot rot	5	1	3
Reproductive disorder	3	2	2
Abortions	1	0	2
Stepped on teats	2	0	0
Services per conception	2.55	4	2.14
Calves	60	4	54
Mastitis cases (cows involved)	15	5	15
Foreign body	0	—	3 cases (2 fatal)
Leukemia (perhaps due to foreign body of long standing)	—	—	1
Peritonitis (calving)	0	—	2
Tumor	1 (fatal)	—	0
Kidney	—	—	1 (fatal)

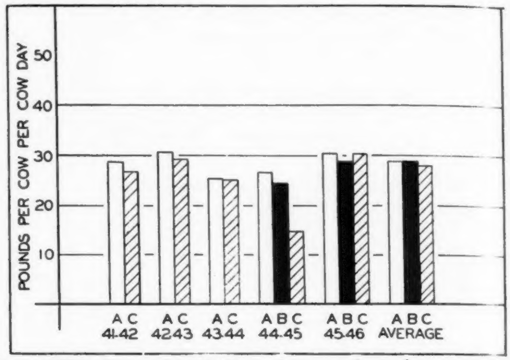


Fig. 10 This shows the FCM per day, as a basis for comparison

Perhaps another measure of herd health is the change in weight of the cows. Over the 5-year period herd A lost 5.6 lb and herd C gained an average of 24 lb per cow for the five test periods. Herd B gained 20.5 lb per cow per test period, since barn B was put into operation. The following table of cow weights summarizes the data for the 5 years:

	A			B			C		
	Begin	Final	Gain or loss	Begin	Final	Gain or loss	Begin	Final	Gain or loss
1941-42	1449	1474	+25				1394	1439	+45
1942-43	1474	1463	—11				1395	1430	+35
1943-44	1444	1452	+ 8				1450	1450	0
1944-45	1362	1305	—57	1354	1366	+12	1398	1406	+ 8
1945-46	1424	1431	+ 7	1430	1459	+29	1420	1452	+32
Avg.	1430.6	1425.0	—5.6	1392	1412.5	+20.5	1411.4	1435.4	+24

Herd Health: Calves. Calves were born in the same barn in which their dams were housed regardless of temperature. A few of barn C calves were taken into barn A to warm and dry off; then they were returned to the cold barn. One calf had the ends of its ears frozen a little, and its nose peeled when it froze to some of the steel equipment. This had no serious effect on the gain which the calf made. Perhaps the best measure of calf health is the record of calf gains shown below.

During periods 1, 2, 3 and 5 a total of 46 calves were born in barn A and 39 calves in barn C. In period 5 two calves were born in barn B.

Two calves, one in barn A and the other in barn C, died at birth, and one calf died in barn C of pneumonia on January 12, 1942, during a period of below zero weather when the pen barn temperatures ranged from 0 to +10F. After this experience calves born in extreme cold weather were dried off and warmed up after birth if they seemed to need it.

AVERAGE GAIN IN WEIGHT IN POUNDS PER CALF PER DAY

	A	B	C
1941-42	1.96		1.92
1942-43	1.82		1.76
1943-44	1.64		1.63
1945-46	1.83	1.77	1.49

The annual range of gain per calf day was from 1.64 to 1.96 lb for barn A, and from 1.49 to 1.92 lb for barn C on a 4-year basis. In barn B for the 5th test period the average gain was 1.77 lb per calf day.

RESULTS

In drawing conclusions on research where variable factors as division of herds of dairy cattle for uniform productive capacity, quality of feed, quantity of feed, total TDN (total digestible nutrients) and barn labor, it is not uncommon for trends to reverse themselves as more data are accumulated. However enough data and experience have been collected both in this barn and on the farms of

cooperating farmers, which when compared with that of other experimenters form a broad basis for the results presented in this paper. Enough of the test data summary has been presented to indicate the basis for the conclusions which follow; a summary of a considerable portion of the data is shown graphically in Fig. 11, for test periods 1, 2, 3 and 5:

1 The cooperating agency was interested in learning the possibility of larger use of steel in the farm building field. The University was interested in developing lower cost, more efficient housing for dairy cattle. Both of these purposes have been fulfilled.

(a) The steel buildings have given excellent service in every respect. No corrosion or deterioration has taken place.

(b) A new method of framing farm buildings has been developed. This is "site-welding"*. As previously reported the development of welding on the job of simple roof trusses and barn frames offers many advantages including lower costs for farm buildings.

2 The daily comparison of ouside temperature and fat corrected milk production did not show a relationship for either the warm stanchion barn or the cold loose-stabling barn. Further studies indicate that there may be a relationship between weekly mean outside temperature averages and the average weekly FCM produced. The 1945-46 data indicate that in the warm barns, A and B, as the average weekly temperature increased from 40 to 60F production went up quite rapidly. However, in barn C the temperature range from 25 to 65F had very little effect on the FCM produced by the herd.

3 The operation of the barns was very well managed so far as the relation of temperature between outside and inside was concerned. Each barn has a characteristic temperature relationship curve from which the deviation was in most cases not more than 10 per cent of the inside temperature.

4 Manure temperatures ran from 80 to 100F in the bedded areas of the loose-housing barns. This warm, soft bed was liked by the cows and should not be disturbed in cold weather. One experience in the first test period with frosted teats occurred during a severe cold period just after the manure pack had been removed. This warm bed is used generously by the cows in cold weather. The deep manure pack preserves the manure and saves bedding. If just enough straw is added so all of it is soaked up and worked

*"New Method of Steel Fabrication for Farm Building Frames." AGRICULTURAL ENGINEERING, vol. 26, no. 10, pp. 415-416, 420, October, 1945.

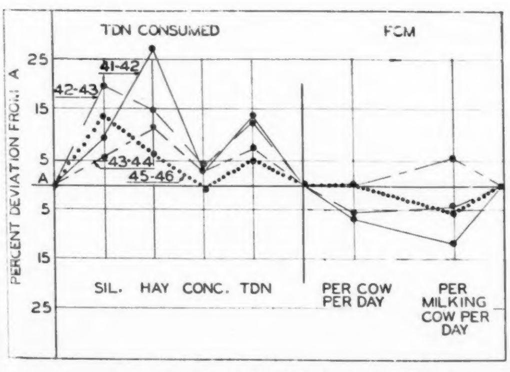


Fig. 11 A summary of much of the data from the Wisconsin dairy barn research project

down into manure, it will be well preserved. Since the manure packs well, head room and a paved floor for the operation of a tractor-mounted manure loader will make it possible to use this important labor saver. Manure stored in this pen barn pack may be hauled to the field at the best time for the efficient use of the manure. While the presence of the manure pack may seem objectionable in the summer, this has not been a serious problem on this project. Further research is needed on the benefits and the sanitary aspects of this manure pack. This would shed some light on one of the questions, How close to the milking parlor should the manure pack be located?

5 Labor comparisons indicates an 8 per cent saving for the loose-housing and milking parlor system. Either system can be mechanized to a greater degree than the barns at the research project have been.

Largely as a result of the acitvities in the line of labor saving on this project the continuous-type mechanical barn cleaner has been lifted from the isolated, homemade jobs to factory production by at least three manufacturers and thousands of copies of the plans and information on barn cleaners have been sent out. Scores of continuous cleaners are now in operation in dairy barns and even poultry houses.

The next operation to be mechanized will no doubt be the automatic feeding of dairy cows by the time clock.

6 Milk production for the winter 6 months in the cold barn C was within 2.7 per cent of that produced in the warm stanchion barn when computed on a FCM (fat corrected milk) basis per cow per day. In the 1945-46 period when the selection of the herd was determined entirely by chance, the production of FCM for A and C was equal. The difference in production of C might be greater over a period of years because of prompt indications of heat periods and better herd health.

7 Feed consumption variations were found indicating that herd A had been fed more concentrates while herd C had consumed more roughages due to the sharp appetite of the cows in the cold barn. The feed manger was shallow in barn C for the first three years and considerable hay was wasted. However, for the five-year period herd C consumed 7 per cent more total pounds of feed and 6 per cent more TDN than herd A.

For a comparison of cost of feeding herds A and C after the feed mangers were rebuilt to eliminate waste of feed in C, the 1944-45 and 1945-46 data were used. The daily cost of feeding a cow in barn A was $0.6538 and in C $0.6266, or the actual cost of feeding herd C was 4.2 per cent less than the cost of feeding herd A. Thus the herd using the greatest amount of roughage had the advantage in cost.

8 Milk in both barns has been well within the requirements for grade A quality. While the logarithmic average of the bacteria counts indicate that barn C produced a milk of slightly higher bacteria count than A for the five-year period, a large percentage of this was due to the dirty condition of the cows in C during the first period. Under properly controlled conditions, the bacteria counts have varied from 2 to 3 thousand between the barns, with barn A lower in two test periods, and barn C lower during one test period. During the last period when barn B was included in the trials, quality of milk produced in it was comparable to A and C for the last three periods.

On the whole, the final factors influencing the quality of milk are the cleanliness of cattle and handling of milk. With both of these factors controlled, little or no difference in the quality of milk produced can be found. A lack of control will, as this experiment has proved, cause a large variation in quality. *(Continued on page 508)*

Weed Control with Chemicals

By L. W. Kephart

MEMBERS of this society, like the public generally, became aware during 1945, through many advertisements and articles in the press of the discovery of a new chemical weed killer of extraordinary potency, a hormone-like substance called 2,4-D. Early claims for this herbicide were sometimes extravagant leading some to believe that the age-long struggle with hoe and scythe, the incessant battle against weeds was approaching an end. Some of the claims of those early days have been borne out by experience, others have not. Regardless of that the discovery of 2,4-D was of very great importance for it aroused public interest in the subject of weed control and brought into focus the fact that weed control as now practiced is an archaic art using time-worn techniques and out-moded, cumbersome machines. The effect of the discovery of 2,4-D may well be even more startling than was at first supposed for it may be the lever long needed to bring about changes in some farm practices regarded as immutable. If it is true, for example, as some say, that spraying and dusting with chemicals will supersede cultivation in the growing of corn, it would mean a change in the methods of growing our most important crop and a change in some of the basic concepts of farm machinery design. Doubtless a prediction so grandiose as this will never reach complete fulfillment, but truth enough exists in the underlying idea that anyone interested in the machinery phase of agricultural engineering would do well to keep a weather eye on developments in the herbicide field during the next few years.

In order to understand more clearly the nature of this approaching change and the part that chemical weed control will play in it, let us briefly review the past. Prior to 1900 chemical weed control was practically of no consequence. Some time prior to 1905 a vineyardist in France made the accidental discovery that copper sulphate was deadly to wild mustard but would not injure cereal crops if sprayed on the grain field while the crop was small. Iron sulphate, a by-product of the steel industry, was found to do the same thing. The discovery aroused much interest. One large American steel company was said to have spent half a million dollars trying to popularize the idea. But the gain evidently was not worth the cost and by 1915 interest in spraying grain fields had largely died away. Nothing more of importance was heard about chemical weed killers until 1925 when, again in Europe and again by accident, it was learned that sodium chlorate, a salt closely related to common salt, but 70 times more toxic to plants, could be sprayed on even the most stubborn perennial weeds with highly gratifying lethal results. A United States patent, later invalidated, was granted on the sodium chlorate process and again interest in the chemical method of controlling weeds reached a high peak. In this case the interest has been quite well sustained for, although the process of weed control with sodium chlorate involves a serious danger from fire and has other disadvantages, the chemical does kill plants better than any other known herbicide, and it is very widely used. Current consumption of sodium chlorate for weed killing is nearly 15 million pounds per year and the supply does not equal the demand.

This paper was prepared for presentation at the annual meeting of the American Society of Agricultural Engineers at St. Louis, Mo., June, 1946, as a contribution of the Power and Machinery Division.

L. W. KEPHART is senior agronomist, Bureau of Plant Industry, Soils and Agricultural Engineering, U. S. Department of Agriculture.

Many other chemicals have been tested for weed control and some had interesting possibilities but only a few have actually come into important agricultural use. Until less than two years ago the list included besides sodium chlorate, only carbon bisulphide, borax, salt, some dinitro compounds and some kinds of toxic petroleum oils. All of these are employed for special well-defined purposes and none of them has had any material effect on the makers or users of farm machines. Had it not been for the discovery of 2,4-D there would be no need to discuss chemical weed killers today.

Prediction is of course a hazardous venture and one would be rash to prognosticate too specifically, but there seems to be good reason to believe that chemical weed control, 5 or 10 years hence, will have a much larger place in the farming picture than it has had in the past.

The change may come quite suddenly. 2,4-D was the opening wedge. In the summer of 1944, 2,4-D, or to give it its full name, 2,4-dichloro-phenoxy-acetic acid, was virtually unknown in agriculture. Except for a few horticulturists, no one had ever heard of it. The substance is an innocent-appearing white powder belonging to a group of organic chemicals that have the peculiar property of altering the physiological functions of plants when introduced in minute quantities into the sap stream. The effect is similar to that produced by the plant's own hormones. Hence the group is known as plant hormones, or more correctly, hormone-like substances or growth regulators. They are not poisons in the ordinary sense. For several years these growth regulators have been employed for such uses as the setting of tomato fruits, artificially preventing the premature drop of apples and improving the color of certain fruits. It was early observed, both here and abroad, that the substance now known as 2,4-D did more than merely regulate plants, for if used beyond the range of 100 parts per million parts of water it caused severe injury. A few far-sighted individuals saw possibilities in this peculiarity and definite attempts to *kill* plants with 2,4-D were made about four years ago. Since then thousands of tests have been made of 2,4-D on large numbers of weed and crop plants and today more than fifty brands of 2,4-D weed killer in seven or eight different formulations are on the market. Thus a substance that was a chemical rarity less than two years ago is now being sold in hundreds of thousands of pounds and creating a whole new industry. Since only two pounds of 2,4-D are needed to treat an acre the potentialities are obvious.

Best known present use of 2,4-D is to kill dandelions, plantains and other weeds in lawns and other turf. For this purpose no other method is even comparable. Of much greater significance, however, are the agricultural possibilities. It is hoped that 2,4-D will be helpful in the control of the so-called "noxious" perennial weeds—bindweed, white top, Canada thistle and other plants for the eradication of which large-scale state and district weed-control programs have been organized. These programs at present are based on tillage and cropping methods of control with some help from sodium chlorate salt and borax. Should 2,4-D prove to be as good as some persons predict, it may largely supplant these more expensive practices with their large-scale use of duck-foot cultivators, dry-chemical spreaders and other machines. Even the fact that 2,4-D requires the use of sprayers and large supplies of water may not be an obstacle. Experiments with 2,4-D dusts have shown some

promise. The big question at present is whether the perennial weeds treated with 2,4-D last year have actually been killed. Inspection parties of state and federal officials are out in the field checking on this. If their reports indicate success, many field cultivators will lie idle next season and the demand for sprayers and dusting equipment will increase substantially.

A second use of 2,4-D which at first seemed to offer much promise was the control of annual weeds in grain fields in the manner originally expected of iron sulphate. Present indications are that 2,4-D is not as safe to use for this purpose as are two dinitro compounds, sodium dinitro ortho cresylate and ammonium dinitro ortho secondary butyl phenol. Both of these are on the market under proprietary names and both have met with ready sale and use.

The situation may be different with corn and it may be here that chemical weed control will seriously challenge mechanical control, at least in those areas where the principal corn-field weeds are not grass but broad-leaved weeds. A few large-scale corn growers have already discarded their cultivators in favor of 2,4-D and have rigged up spraying machines that treat six or eight rows at a time and kill all broad-leaved weeds at one operation. As one operator in California reports, "I spray just once and then sit back and watch the corn grow." Possibly he is an unusually fortunate grower for certainly there are "bugs" in the practice still to be ironed out. Biggest "bug" is the fact that 2,4-D will not kill grasses — either useful or weedy — and pigeon grass and crabgrass are the two most common weeds in corn. Another trouble is that 2,4-D sometimes injures corn. While many fields were sprayed last year with impunity, in others the corn became bent and twisted, lost its tassels, failed to develop brace roots, or in other ways showed that the growth regulator was no respector of species. Yet enough fields came through with excellent results to insure that many corn growers will make a serious effort to take advantage of the important monetary savings of this practice, and that the days of cultivating corn for them, at least, have ended.

A more subtle but perhaps more significant possibility in the same direction and one that would really revolutionize the growing of many garden and farm crops is the chance that 2,4-D may be the means of achieving the much-to-be-desired Utopia of "pre-emergence" weeding. That expression requires a little explanation. By "pre-emergence weeding" is meant the practice of killing weed seeds or weed seedlings in the soil in advance of the emergence of the crop so that the crop will require no hoeing, cultivating, or other kind of subsequent weed destruction. If pre-emergence weed killing ever should become standard practice the cost of producing field crops might well be reduced one-fourth.

The argument in favor of pre-emergence weed-killing is this. All agricultural soils, even those which have been well cultivated, are virtually a mass of living weed seeds as far down as the soil has been plowed. Good farm or garden soil contains as many as 5000 viable weed seeds in every cubic foot. Many of these seeds are able to retain their viability for a long time, some for as long as fifty years. Few seeds will germinate until brought within $3/8$ in of the surface of the soil, and not even then unless conditions of heat and moisture are exactly right for that species. Thus soil may be plowed as many as thirty times in rapid succession or may be cultivated once a week and still have a crop of weed seeds germinating in the upper $3/8$-in layer of soil. It takes a long time to "clean" soil by cultivation.

In pre-emergence weeding the seeds or seedlings of the weeds are destroyed in the upper $3/8$-in layer of soil and the crop is then grown without moving the soil again. There are several ways of doing this. Oldest, perhaps, is the well-known practice of tobacco growers who heat the soil of their plant beds with steam or a wood fire and grow the tobacco seedlings in this sterilized area. Weed seeds also may be killed by treating the soil with chemicals. In some soils a combination of cyanamid and urea is satisfactory; in others the so-called DD is used. On the west coast a machine is being tried that moves across the field treating a 5-ft strip of soil with superheated steam. Another method under test is treatment of the soil with 2,4-D. As little as 3 lb per acre of 2,4-D, costing $3 or less, almost eliminates many kinds of weed seedlings. If used several weeks before planting time most crops can be grown on treated soil with no damage to the crop.

Another system of pre-emergence weeding, restricted however to crops which germinate slowly, is to plant in the regular way and then a day or two before the crop is due to appear above ground spray the weed seedlings with a suitable herbicide, or sear them with weed burners. The crop is never cultivated since stirring the soil stirs up another set of viable weed seeds.

Still another kind of pre-emergence weeding, and one that should appeal to the ingenuity of agricultural engineers, is a system in which the soil is thoroughly prepared, the fertilizer placed in the rows and the ground then left undisturbed for from 3 to 7 days. During that time most of the weed seeds that are going to germinate do so. A quick once-over treatment with a battery of weed burners or a sprayer then disposes of most of the weeds for that season. Immediately before or after this treatment the crop is planted exactly in the prepared rows using a planter that causes the least possible disturbance of the soil in placing the seed. Several new machines for doing this are being tried. In one the planting shovel is a thin knife-shaped edge which slices through the soil with very little furrow opening, deposits the seed and then gently rolls the soil back in place almost in the original position. On some soils this devise works surprisingly well. Another inventor uses a stabbing motion to deposit the seed in the soil somewhat after the manner of an old-fashioned hand corn planter. A well-designed stabber disturbs the soil scarcely at all. Whatever the means employed the object is to leave the soil in place and not bring another crop of weed seeds to the surface.

To many the thought doubtless will occur that any method of controlling weeds in row crops by pre-emergence weeding chemical or otherwise eliminates intertillage of the crop. And that, to some, is little less than heresy. Let it be remembered, however, that intertillage has been known for more than 30 years to be a highly questionable practice and much of it would have been stopped long ago if any other means were available to control weeds. The evidence is conclusive that the principal function of intertillage is to kill weeds, and, except under special circumstances, the practice often does more harm than good. Certainly intertillage is a clumsy wasteful way to do a relatively simple thing, and it is no great compliment to our intelligence that a better method has not been found.

Many other kinds of weed-control problems seem destined to be solved by the chemical method. One of the real disgraces of American civilization is the fact that thousands of persons suffer torment each year from hay fever. The economic loss to the nation from their distress is incalculable. Ninety-five per cent of all hay fever is caused by the pollen of ragweed. Yet ragweed is one of the easiest plants to destroy with 2,4-D or other herbicides. What greater boon can be imagined than to wipe ragweed

from the face of the earth. It could be done for the price of one battleship.

Some of the heaviest sufferers from weeds are the railroads. More than 350,000 miles of main-line track and hundreds of thousands of miles of sidetrack must be kept wholly or partially free of vegetation. Thus far the only methods available to the railroads are hand weeding (a grotesquely costly process), burning with weed burners (which is only a palliative), and spraying with chlorates or arsenicals (both dangerous and expensive). The railroads obviously need help. Nor are they the only ones who need a chemical that will kill all kinds of plants and keep them killed. Power transmission lines, oil tank fields, irrigation and ditch banks, forest-fire lines, and many other situations cry out for a sterilizing chemical that is reliable, non-inflammable, non-poisonous, and cheap.

Pasture and range lands throughout the world are infested with brushy or shrubby types of weeds that cannot be controlled by any ordinary means. Mesquite, scrub oak, scrub pine, sassafras are common examples. The island of Cuba has a serious infestation of marabu, a thorny leguminous shrub. There are many others. The problem is to find a cheap and effective herbicide and an equally effective machine for applying it. Here is a challenge worthy of any imaginative engineer.

Aquatic plants that clog lakes and streams are a constant and heavy source of loss. Most famous is the water hyacinth which for more than forty years has choked the streams, canals, and bayous of the Gulf Coast region with an impenetrable mass of floating vegetation. The federal government spends hundreds of thousands of dollars a year to chop temporary passages through the mass but the beautiful pest remains a multimillion-dollar headache to Florida and Louisiana. Fortunately 2,4-D seems to be deadly to water hyacinth and the end of the gorgeous tyrant may be in sight. Still the western irrigated states spend huge sums of money to drag heavy ship's anchor chains down the canals or use other strong-arm methods in an all but futile effort to keep their waterways clean. Surely chemists and engineers together can find better ways than that.

I have sketched in these paragraphs the general outlines of the future place of chemical weed control. The details are available elsewhere. The point that I want to establish is that weed control is a tremendous problem of extraordinary complexity that cuts across virtually every field of agricultural enterprise. Yet it has received only slight attention from scientists and engineers. Ten years ago there were in the United States some 900 entomologists, about 600 plant pathologists, 250 animal pathologists and hundreds of other specialists in diverse and important agricultural subjects. But in all the land there were precisely three men who devoted full time to the investigation of weed control. Today that number, happily, has increased. But there still remains a wide-open field for men with imagination, courage, and skill to see the opportunities in the business of better weed control and to contribute handsomely to their own and the country's welfare through this means.

Correcting a Misunderstanding

(Continued from page 497)

assurance that it may ultimately find some useful application in agriculture. Agricultural engineers readily acknowledge their great debt to other branches of engineering for improvements of materials, techniques, devices, basic data, and other means of strengthening the engineering foundation of agricultural engineering.

They can apply themselves to development of consumer goods which farmers might use as individuals, in common with other people, rather than as farmers. Farmers have made good use of the automobile and of hundreds of other engineered products requiring no special adaptation for use away from city streets and facilities.

Or they can devote their attention to the improvement of component materials or parts common to farm and other equipment, such as a carburetor which requires minimum special adaptation for farm use; or to some major equipment unit, such as an electric motor, for which farm use imposes few requirements not found in some other industry; or to some major structural work, such as a large dam, for power and irrigation development.

It is to our interest to apply these corrective measures wherever the need shows up, not with a view to monopolizing the field for a select few, but to clarify the prerequisites for fruitful work in agricultural engineering.

Dairy Barn Research

(Continued from page 505)

9 Herd health of cows and calves was good in both barns. In a number of ways the loose-housing barn C showed advantages, and then there were some disadvantages. Adjustments were made to eliminate difficulties as the work progressed. It still remains necessary, however, for one to work in the cold barn in order to take care of a herd housed in one.

Herd C had no cases of stiffness, stepped-on teats, injured knees or hocks. There was one case of lameness. Heat periods were quickly detected and herd C had 16 per cent less services per conception.

The cows in barn C were dehorned as in barns A and B and the feed bunks were built deep with cross bars every five feet to prevent crowding. No boss cows developed, except that a lone Jersey in barn C one year was too timid to step up and take her place at the feed manger while the other cows were eating.

All deaths due to foreign bodies occurred in barn C. Post mortem examinations indicated the foreign bodies had most likely been present for some time and no tie-in with the barn could be found.

Calf gains were very little higher in A than in B. The death of a new-born calf by pneumonia in the cold barn at or near zero temperature indicated the need for drying off after birth in a warmer place. After being dried off and warmed up they were safely returned to their cold barn.

In general it can be said that cows housed loose may have longer productive lives because of fewer injuries, less stiffness and a sharper appetite. They will eat more roughage and less concentrates under this system of management. For old cows that have established high production records, the loose-housing system offers a way of keeping them going in good production, and this offers an opportunity for more good calves.

REFERENCES

Open Stable versus Closed Stables For Dairy Animals, S. S. Buckley; also The Bacterial Content of Milk Produced in the Open Stable and in the Closed Stable, R. W. Lamson, Bulletin No. 177, Maryland Agricultural Experiment Station, May 1913.

The Effect of Open-Shed Housing as Compared with the Closed Stable for Milking Cows. Director's Report, 1916-17, Bulletin No. 147, Pennsylvania Agricultural Experiment Station.

Relation of Stable Environment to Milk Production, Kelly and Rupel. USDA Technical Bulletin No. 591, November, 1937.

Pen Barn and Separate Milking Room, McColly and Dice, North Dakota Agricultural Experiment Bulletin 283, January 26, 1935.

Analysis of Types of Fans for Curing Hay in the Mow

By Thomas Cranage
MEMBER A.S.A.E.

As agricultural engineers you are primarily concerned with providing the farmer with proper tools, methods, and know-how so that what he produces will give him the greatest income with least cost. Relative to curing hay in the mow this means that he must produce the best possible grade using the minimum kilowatt-hours per ton of hay. Realizing that such factors as time of drying and cost of equipment enter into the problem, the engineer must consider first some other factors which affect the selection of a fan for curing hay in the mow.

The usual limiting factor is the available horsepower. In most cases he can use the maximum volume of air that can be delivered from the available horsepower. For example, on most farms at the present time the maximum power available would be the 5-hp single-phase electric motor.

To determine the type of fan to be used for curing hay in the mow, it is necessary to know what the desired performance of the fan should be, namely, the maximum cubic feet per minute it should deliver and the static resistance in inches, water gage, it should be able to overcome. This, of course, is an impossible thing to determine exactly as it has been found there is a wide variation in resistance to the same flow of air through different hay and different conditions of hay. It therefore behooves the engineer to choose a fan that as nearly as possible will be able to meet the varying conditions encountered. What he would like to have would be a fan that will give the maximum volume, at the time, that the hay mow contains its maximum amount of hay, and at this time, of course, there would also be the maximum resistance pressure to the flow of the air through the hay.

The varying conditions are summarized in Fig. 1. Considering only the hay, it is easy to see that a shallow pile of long hay loosely packed will have a low resistance to air passing through it. Likewise, a deep pile of short-cut hay tightly packed would offer a high resistance to the passage of air.

Considering also the fact that the fan must push air through a series of ducts before the air gets to the hay, it follows that the total resistance is made up of a variable plus a fixed resistance for any given volume. Fig. 2 shows that the total resistance which must be overcome is the sum of the hay resistance and the duct (and other) resistances.

All resistances are figured to terms of pressure at the fan. In Fig. 3 the man represents the power driving the fan. The hose and pile of hay are physical aspects of *the system*. The curves are *system characteristic* curves. They show that for any given volume the high-resistance system will require more pressure at the fan than will the low-resistance system. It is important to get the concept of system characteristics. On either system it requires increased pressure to force an increased volume through the system. If there were a fan that would give a performance that follows the system characteristic, it would be ideal.

However, all fans regardless of make or type, when run

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at St. Louis, Mo., June, 1946, as a contribution of the Rural Electric Division.

Thomas Cranage is district sales manager, the Clarage Fan Co.

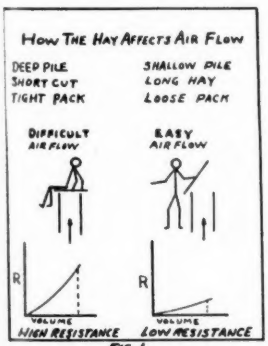


FIG. 1

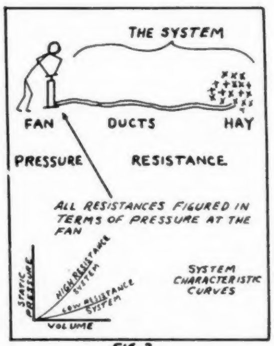


FIG. 3

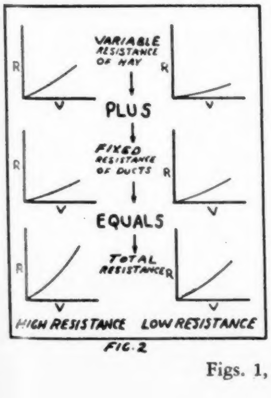


FIG. 2

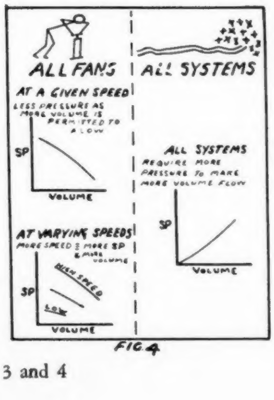


FIG. 4

Figs. 1, 2, 3 and 4

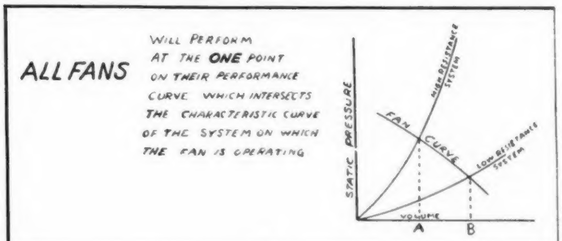


FIG. 5

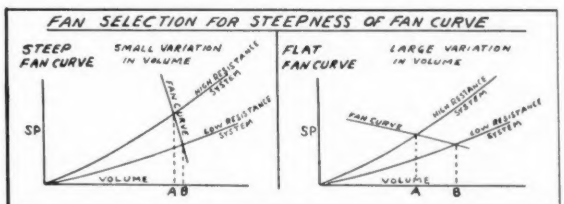


FIG. 6

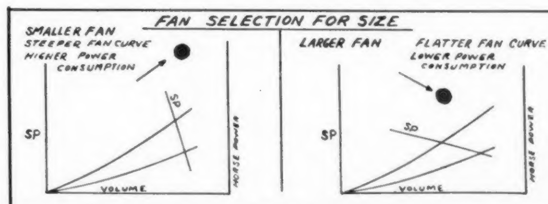


FIG. 7

Figs. 5, 6 and 7

at a constant speed, have a performance which is just the opposite of the system characteristic. All fans at a given speed produce less pressure as more volume is permitted to flow. This is illustrated in Fig. 4.

Also, as illustrated in Fig. 4, there is only one way that a simultaneous increase of volume and pressure can be obtained with any type or make of fan, and that is by varying the speed of the fan, thus running it at a higher speed for maximum volumes and pressures for deep hay and at a lower speed for thin hay where minimum volume and pressure are needed.

As illustrated in Fig. 5 all fans will perform at one point and only one point on their performance curves. The fan performs at the point on its performance curve that intersects the system characteristic curve of the system to which the fan is attached. For example, the fan would give volume A if used on one system, or would give volume B if used on a system with lower resistance. For this reason, the steepness of the fan curve where it crosses the system characteristic curve is an indication of what will happen as the system changes. Fig. 6 demonstrates that, when there is an increase in the resistance of the system, or, in other words, when the fan is required to change from operation on a low-resistance system to operation on a high-resistance system, the decrease in volume is less if the fan has a steep performance curve than if the fan has a flat performance curve. For any type of fan, the smaller fan that is used the steeper the curve will be for a given volume, and it will be more desirable on a hay-drying installation, except when too small a fan is used, the velocity becomes so high that too much power is used up in velocity pressure and the attendant losses (see Fig. 7).

Fig. 8 is a reprint of Table 1 of Bulletin No. 105, (1946), entitled "Standard, Definitions and Terms in Use by the Fan and Blower Industry". This figure shows the four basic types of fans as defined by the various engineering societies, the National Association of Fan Manufacturers, the Army, the Navy, and other government agencies, namely, (1) propeller fan, (2) tubeaxial fan, (3) vaneaxial fan, and (4) centrifugal fan. The A.S.A.E. would use sound judgment to follow this nomenclature and avoid a lot of misnomers that the fan industry has been faced with for years, due to the practice of different individuals and manufacturers in the early stages of the industry giving their own pet names to some type of fan and very much confusing the buyer whether he is an engineer or a layman. The four basic types may be made with various wheel designs, and of course have various trade names. For this paper we are considering only fans suitable for hay drying. These are the high-speed propeller fans, the centrifugal fans, and the vaneaxial fans. We will not consider the slow-speed types of propeller fans which are suitable only for free delivery such as in kitchen or attic exhaust as they are entirely unsuitable for hay curing. Neither will consideration be given to the tubeaxial, as it has very little value over the propeller fan for hay drying.

Figs. 9, 10, 11 and 12 illustrate typical constant speed curves of the backwardly curved blade centrifugal, the forwardly curved blade centrifugal, the high-speed propeller, and the vaneaxial fans. These curves are plotted on a percentage basis. Static pressure is based on the pressure at no delivery as 100 per cent. Volume on the horizontal line is based on volume at free delivery against no resistance as being 100 per cent. The brake horsepower for the two types of centrifugal fans is based on 100 per cent brake horsepower being at free delivery when there is no resistance pressure. The brake horsepower for the propeller and the vaneaxial fans is based on 100 per cent brake horsepower being at no delivery and maximum static pressure. On each static pressure curve, the range for maximum mechanical efficiency is shown by shading. This is the range in which the fan should be operated if the farmer is going to get best value for the electric current he is buying.

Backwardly Curved Blade Fan (Fig. 9). This fan is

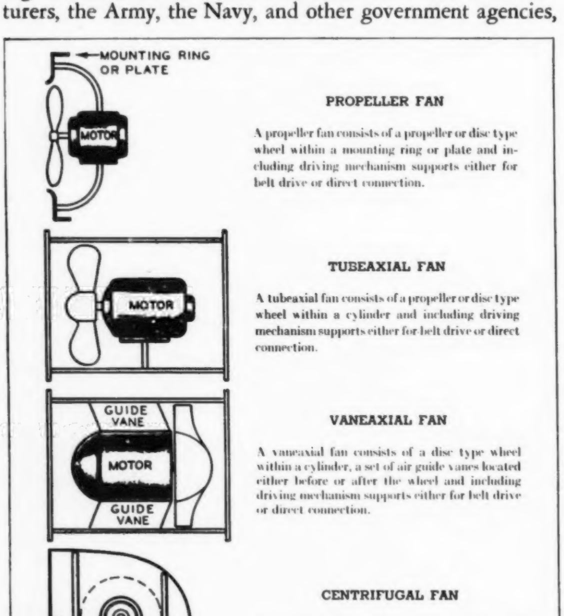


Fig. 8

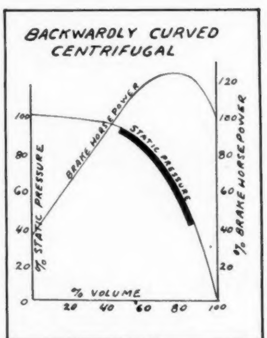


FIG 9

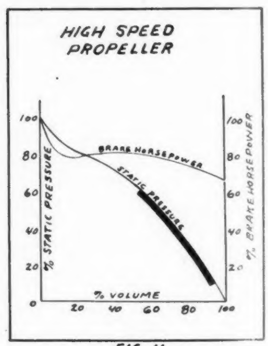


FIG. 11

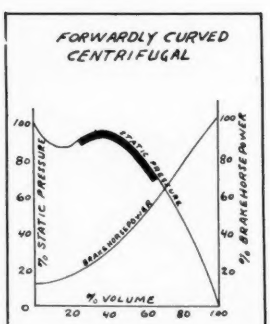


FIG. 10

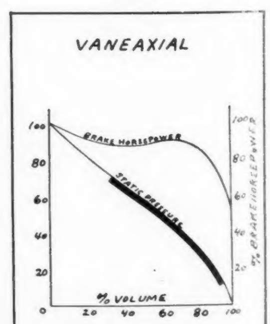


FIG. 12

Figs. 9, 10, 11 and 12

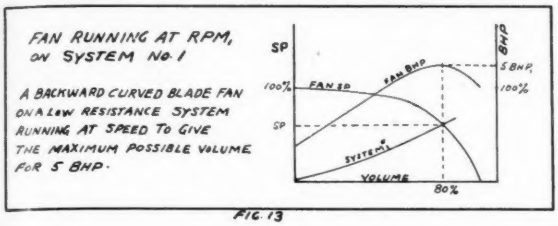


FIG. 13

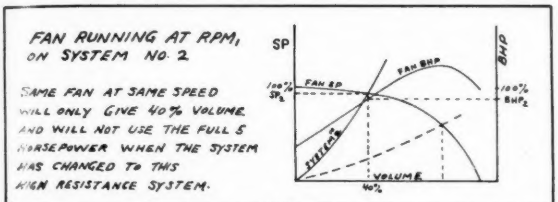


FIG. 14

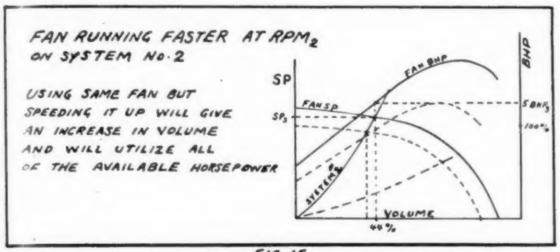


FIG. 15

Figs. 13, 14 and 15

made in all sizes and is suitable for any volume or pressure that might be desired. In order to get the maximum capacity out of it for hay drying, this fan should definitely be equipped so that its speed can be changed. If the fan is belt driven, this can be done with an adjustable pitch sheave, or with sheaves that can be changed. The reason for changing speeds can be illustrated by an example.

Let us take some hypothetical figures as follows (see Fig. 13). Say that 80 per cent volume equals 15000 cfm, and at a given speed of 468 rpm the fan produces this volume at 60 per cent static pressure which is 3/4 in, and the brake horsepower of 124 per cent is 5 bhp. This condition is with a low-resistance system (a light load). When additional hay is put in the mow, there is a new system of higher resistance on which the fan must operate (see Fig. 14). With this fan running at a constant speed, it would now give, say, 40 per cent volume, or 7500 cfm, and the resistance pressure would be 1.21 in with a brake horsepower of 91 per cent or 3.68 bhp. Quite obviously this is an impractical place to run this fan, as not all of the motor horsepower is being used and the maximum drying job is not being done. Therefore as illustrated in Fig. 15 the fan should be speeded up approximately 11 per cent to deliver 8300 cfm, in which case the resistance pressure would be 1.49 in, and the brake horsepower that the fan would use would be the full 5 hp. While this fan has a self-limiting horsepower characteristic within its maximum efficiency range of operation, this characteristic does not really have the value that so many people believe because it would be impractical to run it at a constant speed just so it could not overload the motor at that speed. The mechanical efficiency of this fan is about as high as any fan made. This fan is a quiet operating fan. Under present manufacturing conditions, I believe this fan is too expensive for the average farmer, and its inherent cost of manufacture is such that I doubt very much whether it will be used very extensively except for large farms that can evaluate the cost.

Forwardly Curved Blade Fan (Fig. 10). This fan has the same general characteristic as the backwardly curved blade centrifugal fan, except that it is not quite as efficient and does not have quite as wide a range of efficiency, but it is still adaptable to variable-speed control so that the maximum pressure and volume conditions can be reached within the horsepower of the motor. It does not have the self-limiting horsepower characteristic of the backward curved blade fan, but as pointed out previously that characteristic does not really have anywhere near the value that so many people have placed upon it. The important thing is that on this fan as well as on the backward curved blade fan, the fact that the horsepower drops off when the fan is placed on a higher resistance system is a distinct advantage because it permits speeding up of the fan to get the maximum volume possible with the horsepower available. This fan is also a quiet fan running at very low speeds. The cost of this fan, due to existing volume production in quite a few fan companies not only for hay drying but for many other uses on which the same parts are used, is very reasonable for the type and quality of equipment received.

High-Speed Propeller Fan (Fig. 11). The design of this fan is such that it is primarily adaptable for constant-speed operation. Its efficiencies for lower static pressures are comparatively good. By looking at the performance curve, it can be seen that this fan takes practically the same horsepower for all conditions of delivery and pressure, so that its efficiency at higher pressure falls off, and due to this characteristic cannot be speeded up to meet a condition of higher resistances except by varying the horsepower input. In other words, when the depth of hay and the quantity of hay is the greatest, the condition under which the most air is needed, this fan will deliver the minimum volume per horsepower input. For low pressures, however, this is probably second in efficient operation to the vaneaxial fan and no other. Tip speeds of propeller fans suitable for hay drying are such that they are inherently higher in noise level than the other types. The cost of this fan is comparatively low.

Vaneaxial Fan (Fig. 12). This is a type of fan that various fan companies have been developing and working on for quite some years. Its development was accentuated during the war as it was a basic type of fan used by the Navy. It can be built to give any volume desired or any pressure desired. It has the same disadvantage as the propeller fan in that at constant speed it has a flat horsepower curve, but its efficiency is so high (equal to or better than that of the backwardly curved blade fan) and its pressure curve is steep (giving good range in pressure with little decrease in volume even at constant speed) that it compensates for the penalty of the flat horsepower curve. Even at a constant speed it is probably equal to or better than the backwardly curved blade fan at a variable speed. Its speed is approximately two-thirds that of the high-speed propeller fan, and about double that of the backwardly curved blade fan or the forwardly curved blade duplex fan; so that the possibility of off-balance is approximately halfway between the high-speed propeller fans and the centrifugal fans. This fan can be either reasonably quiet or rather noisy, depending on the system characteristic on which it is operating. Generally speaking it will never be as quiet as the two centrifugal fans, but it will never be as noisy as the propeller fan.

The cost of this fan at the present time is too high for the average mow hay-drying installation, but if manufacturers can ever bring it to a cost range that is practical without sacrificing too much efficiency it will certainly be one of the most desirable.

Laboratory and Field Tests. As the method of testing fans in the laboratory for publishing performance tables and the testing of fans in the field to see what volume is flowing through the hay drier is such an important point in the choice and use of fans, I will discuss it briefly. Fans in general are tested as exhausters or as blowers. For hay drying any performance tables should be based on fans tested as blowers attached to duct work since up to the present time the only application has been of blowing air through ducts into the hay.

Plate I (Fig. 16) from the standard test code for centrifugal and axial fans illustrates the proper laboratory setup for centrifugal fans tested as blowers with duct work. Plate VII (Fig. 16) illustrates the proper laboratory test setup for propeller or vaneaxial fans tested as blowers with duct work. These are the only two test setups that apply for fans to be used in hay drying where the fan blows through ducts to the hay.

Fig. 17 shows some of the setups which are not suitable for hay drying fans. Plate VI shows a test that is inapplicable because the test gives values for a fan without any ducts. Code tests, Plates II and VIII, for exhaust fans with duct on inlet should never be used because such tests give results that apply only when the fan is exhausting.

In publishing fan tables as a result of laboratory tests, the manufacturer should show the volume (cfm), the static pressure (sp), the speed (rpm) and the horsepower (bhp) at all conditions under which the fan is going to operate, so that the buyer will know whether he is buying a fan suitable for the job and whether he is running it at the right speed, and also what actual brake horsepower will be required at specific conditions of performance. In the merchandising field which covers small fans both centrifugal and propeller, it has been the practice of all manufacturers at various times merely to give the volume delivered at the pressure, and to state that the fan is connected to such and such a horsepower motor, feeling that the range in which the fan will be used is such that there will never be any trouble. This practice would be all right for hay-drying blowers, provided a table is also given showing the brake horsepower that the fan will require for various conditions of operation. This showing of the brake horsepower is important to the user.

There has been a lot of conscientious field testing of fans and systems on hay-drying installations by agricultural engineers and power company engineers, and practically all men who have done this testing have found that it is very difficult to get accurate readings. The testing in most cases boils down to an accurate reading of the speed of the fan and of the kilowatt input or horsepower input to the motor. With the kilowatt input readings the test men can use data from the motor manufacturer to calculate the horsepower actually delivered to the fan. It is important to use delivered horsepower instead of horsepower input to the motor. They then try to check their static and volume readings against the fan manufacturers' tables, and where they cannot check with these, they take the fan tables as correct. From a practical standpoint this is really not as bad practice as it sounds, but it further illustrates the necessity of having all tables for hay driers based on tests of blowers with ducts. With the backwardly curved or forwardly curved centrifugal fans this method is much more accurate than it is with a propeller or vaneaxial fan, as the horsepower varies considerably with deliveries with the first two types and remains almost constant with the second two types. This necessitates more careful reading of pressures and velocities with the propeller and vaneaxial fans. In addition to spiral discharge developed by the propeller fan, a wavy discharge

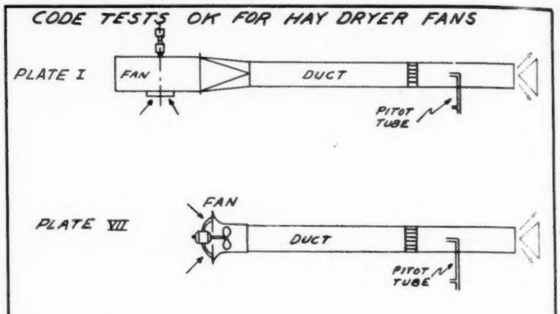


FIG. 16

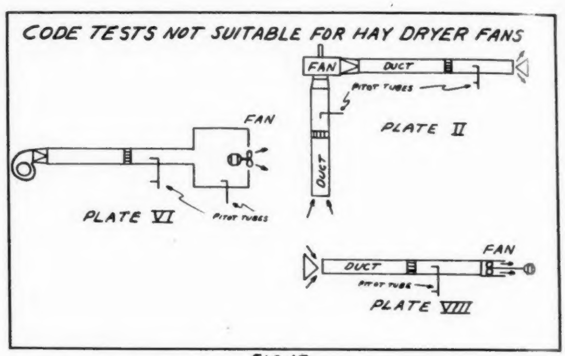


FIG. 17

Figs. 16 and 17

has been reported by some sources for centrifugal fans. The possibilities of encountering these types of flow in the main duct is brought to your attention at this time so that if any attempt is made to measure volume by pitot tube or velometer proper correction for angularity of flow should be made.

In conclusion I would say that characteristics of the system on which the fan is used determine how the fan will perform. Therefore, it is necessary to determine as closely as possible what the variation in required volume will be and what pressures will be necessary to make these various volumes flow through ducts and hay. For all fans running at a given speed the pressure produced decreases as an increased volume is permitted to flow. It is therefore advisable to operate the fan at different speeds to take full advantage of the limited horsepower available and get the maximum volume possible. The centrifugal fans lend themselves to speed changes more readily. The propeller fans are inherently constant speed and constant horsepower. Manufacturers' performance tables to be useful for hay drying jobs must be based on tests of blowers through duct work. Field testing of capacity is facilitated by checking with a capacity and horsepower table in the case of centrifugal fans. Fans that give the air a spiral motion on discharge to the duct make intelligent field testing impractical. Vaneaxial fans have many desirable characteristics and should their price become low enough they would be good for hay drying.

Information is available from reliable sources that hay drying or hay finishing has been done very successfully with resistance pressures of approximately ½ in water gage. In most of the cases reported for this low-pressure operation, either the hay was put in after considerable field drying had been done so that little additional drying needed to be done by the fan, or very shallow piling of the hay was used. From a commercial standpoint we cannot depend on the

farmer to keep his hay in the field until it gets down to these low moisture contents; therefore, the manufacturers must furnish fans that will pass air through the hay at higher velocities and the consequent higher resistance pressures.

Discussion by H. E. Sproull

THE FORWARDLY curved blade hay-curing fan operates at the lowest wheel tip speed of any fan produced. When the velocity pressure is one-eighth to one-sixth of the resistance pressure, the fan is working at its best efficiency. It produces 1½ in wg resistance pressure; for example, when the wheel tip speed is only 3500 fpm, the velocity pressure then would be 0.25 in, or an air outlet velocity of 2000 fpm, which is the correct outlet velocity for 1½ in resistance pressure. The wheel tip speed and fan outlet velocity relation is not at all critical, as this fan has very flat characteristics.

A number of well-made makes of multiplate V-belt drives allow close coupling on short centers, economizing space; hence the motor can be isolated entirely from the fan structure. This permits the use of standard motor frames.

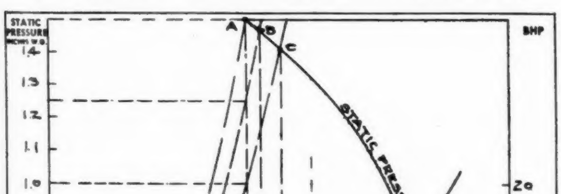
In addition to being quiet in operation, requiring small floor space and low driving power, the forwardly curved blade hay-curing fan has many other desirable characteristics. Its low speed is conducive to long life, its proportions lend themselves readily to rugged mechanical design, and the construction of this type fan wheel makes perfect rotative balance easy to attain and maintain.

Forwardly curved blade fans have flat load-limiting operating characteristics, and this valuable trait can be shown by the following actual example.

Assume a specification calling for 17,120 cfm at 1½ in resistance pressure. By referring to published capacity tables it will be noted that a No. 2 - 21-in hay-curing fan has the specified capacity as to volume and pressure when operating at 639 rpm and will require 7.5 bhp.

Presume for a moment that an error of 20 per cent was made in estimating the pressure of the system and that when passing 17,120 cfm the actual resistance was found to be 1¼ in instead of 1½ in as specified. It is evident that, under the circumstances, the fan when operating at 639 rpm will deliver more air than originally contemplated and will require more power to operate than specified.

H. E. SPROULL is divisional manager, American Blower Corp.



Performance data of a No. 221 ACH Sirocco hay-curing fan. The curves are based on a constant speed of 639 rpm

The amount of increase in these two items, due to overestimation of resistance pressure, has been greatly exaggerated by some inexperienced in the use of basic forwardly curved blade fan performance data. It might be assumed that, by referring again to the tables in the case cited above and by locating a speed of 639 rpm, under the 1¼ in resistance pressure, the performance of the fan under the new conditions would be immediately indicated. This is not the case, however, as it will be further noted that the No. 221 hay-curing fan, when operating against 1¼ in static pressure and at 639 rpm, will deliver 24,600 cfm and require almost 11.6 bhp. A system requiring 1¼ in resistance pressure to force 17,120 cfm through it would require 2.37 in resistance pressure to force through 24,600 cfm. The No. 221 fan at 639 rpm would not produce this much pressure, so it is impossible to disregard the system in determining the fan performance.

Performance curves of No. 221 forwardly curved blade hay-curing fans are shown with the fan operating at 639 rpm. On this same curve may be superimposed a system curve for any assumed condition of error. Where the fan curve and the system curve cross will be found a condition which satisfies both the fan characteristics and the system characteristics and indicating volume and pressure figures as they will actually occur. A sample of these curves accompanies this discussion. Three system curves have been superimposed on the fan curve: A as originally estimated and B as discussed above, wherein an error of 20 per cent was made in estimating the resistance pressure, which shows the performance of the fan to be 18,200 cfm, 1¼ in resistance pressure, 639 rpm, and 8.1 bhp. The C curve has been added showing the resultant operating conditions in the case of a 50 per cent error in estimating the resistance pressure. In this third case the performance of the fan would be 20,150 cfm, 1.00 in resistance pressure, and 9.0 bhp. Thus when the resistance pressure was overestimated 20 per cent, the air increased 7 per cent and the power 8 per cent. When the resistance pressure was overestimated 50 per cent, the air increased 18 per cent and the power 20 per cent.

In the case of the fan selected above, at 639 rpm, the 7½ hp, 40C N.E.M.A. motor originally specified would carry the load temporarily and would provide for errors up to 50 per cent in resistance-pressure estimations.

The air duct system is always a fixed orifice to the air flow from the fan, and always offers a definite amount of resistance dependent upon the volume of air flowing. The variable element in the total resistance against which the fan operates is then the depth of hay in the mow. To compensate for this undetermined variable element, all ACF hay-curing fans are fitted with an aileron control damper in the fan outlet, which is an efficient method of air volume and pressure control. The aileron consists of an auxiliary scroll sheet manually adjusted by a connection rod. The outlet of the fan is thus modified to give the wide range of air volume and pressures.

It requires no technical expert to adjust this control. On most installations overload protection is used in the motor circuit so that, if the farmer should operate the hay-finishing fan with the mow empty, the fan would handle considerably more air at the free-delivery conditions, and should the overload control on the motor trip out, it would only be necessary for the farmer to loosen one setscrew and push the aileron control rod partly closed. The blower would then operate without tripping out the motor, and after the mow is partly filled and when *(Continued on page 517)*

Physiological Backgrounds for Psychroenergetic Studies

By Dr. Samuel Brody

IT SEEMS that the author is the only survivor of the four speakers on the symposium on this subject at the St. Paul meeting of this group in 1939. May the memories of M. A. R. Kelly, Max Kriss, and J. R. Dice be an inspiration in our work.

Agricultural Progress and Population Growth. By way of introduction, I should like to quote an apparently irrelevant passage from a famous book:

> In the next 25 years the population of the Island will be 28 million, and the means of subsistence only equal to the support of 21 million. In the next period, the population would be 56 million, and the means of subsistence just sufficient for half that number.—T. R. Malthus, 1798.

Malthus' prophecy of increasing starvation with increasing population did not materialize, at least not as it concerns the United States. Our population has increased from 4 million in 1798 to 141 million in 1946, and there is still no starvation; on the contrary, the standard of living has been rising. This was made possible by increasing the rate of food production based on increasing knowledge and enterprise.

For instance, the best European livestock were imported and developed to almost unbelievable productive heights. We now have cows that produce some 55 qt of milk a day; chickens that lay an egg almost every day in the year; pigs that reach the market weight of 225 lb in but 6 months at a cost of only 4 lb feed per pound gain in weight; steers that reach the market weight of 900 lb in but one year at a cost of only 4 lb TDN (total digestible nutrients) per pound gain in weight. Such animals are rare, but they demonstrate what can be accomplished with the aid of knowledge and enterprise.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at St. Louis, Mo., June, 1946. It is approved as a contribution from the department of dairy husbandry, Missouri Agricultural Experiment Station, Journal Series No. 1019.

SAMUEL BRODY is professor of dairy husbandry, University of Missouri.

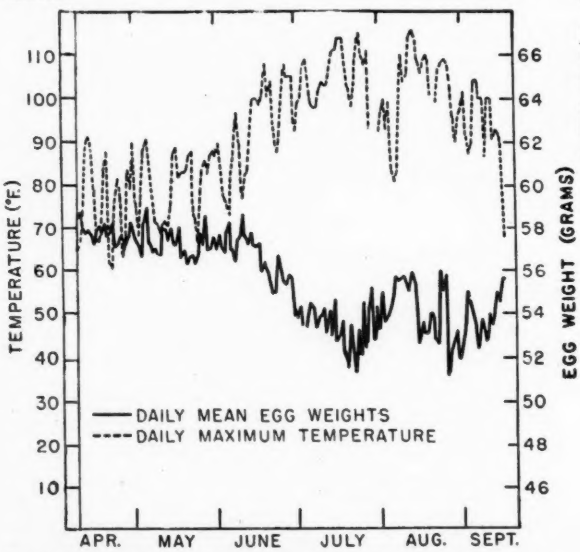


Fig. 1 Egg size in relation to environmental temperature. (Courtesy D. C. Warren, J. Agr. Res., *59*, 443, 1939. See also Poultry Sc., *19*, 67, 1940)

High Temperature as a Major Obstacle to High Production. These upper productive levels are rarely achieved often because of unfavorable temperatures. Some regions are too cold in the winter but most are too hot in the summer. In the United States hot weather is a more serious obstacle to high production than is cold weather for two reasons. First, we know how to keep farm animals warm in winter but not how to keep them cool in the summer. Second, our best dairy cattle were evolved in cool climates, such as Holland, Demark, Scotland, and the Channel Islands, yet they are concentrated in the Middle West and other regions subject to climatic extremes to which the animals are not adapted. No matter how good the inheritance and feed supply, an animal cannot attain a high productive level when the environmental temperature is near that of the body. There is urgent need to develop methods for eliminating the high-temperature menace to production. But before developing such methods physiologic data must be had on the effects of climatic factors on animals.

Temperature and Body Physiology. An unfavorable temperature, like an unfavorable food supply, exerts an unfavorable effect on the body physiology—on its hormones, enzymes, and nutrient levels—and in this way exerts an unfavorable influence on the productive rates.

For instance, the thyroid hormone, thyroxine, is essential for high production of milk, eggs, and so on; but thyroxine production is profoundly influenced by temperature. C. W. Turner, of the Missouri Agricultural Experiment Station, observed (1946) that chickens produce twice as much thyroxine in winter as in summer; Atwood and Dempsey reported (1943) that rats produce about six times as much thyroxine at 34 F (degrees Fahrenheit) than at 95 F. This decrease in thyroxine with increase in temperature is one possible factor in the decrease in milk, egg, and meat (growth) production with rising temperatures. Other hormones, enzymes, and nutrients may be similarly influenced by temperature and they in turn may influence the productive rates.

For instance, Conrad (1939) reported that the calcium level in the blood of chickens decreased by 30 per cent when the temperature was raised by 20 F, from 70 to 90 F. Since blood calcium is a precursor in egg production, it is not surprising that increasing temperature which decreased blood calcium also decreased shell thickness, egg number and egg size (Fig. 1).

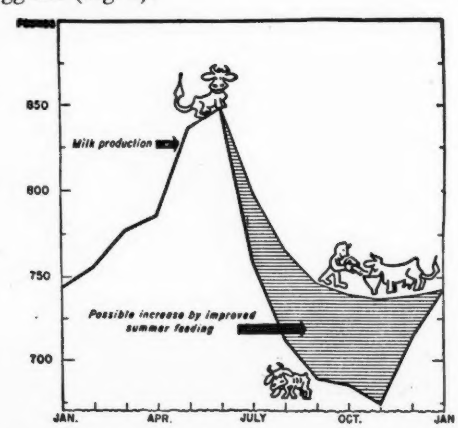


Fig. 2 Milk yield in relation to season. (Courtesy USDA)

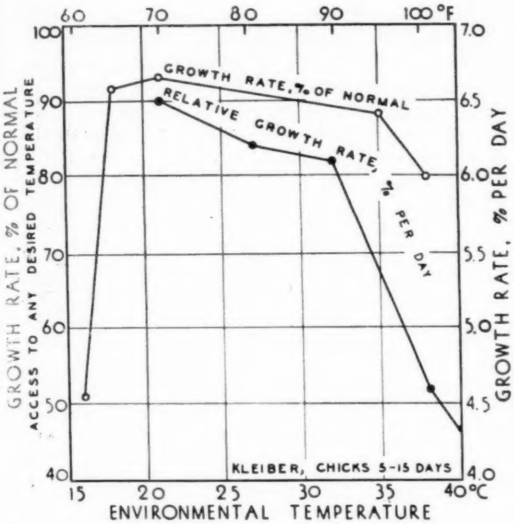


Fig. 3 Influence of temperature on growth of chicks. (Courtesy M. Kleiber)

Similar statements might be made for milk production (Fig. 2), growth (Fig. 3), and other productive processes. There is an optimal temperature for every productive level, body size, age, body color, and so on. Fig. 3 shows in striking fashion how the growth rate of chicks drops rapidly on both increasing and decreasing the optimal temperature of 70 F. This temperature is optimal only for the given birds under the given conditions. The numerical value of the optimal temperature varies with many circumstances.

Body-Temperature Regulation and Methods of Heat Dissipation. Body-temperature regulation is very efficient in most farm animals at temperatures below 70 F. For instance, the rectal temperatures of horses, cattle, and sheep do not decline even by 1 F when the winter air temperature drops seasonally to about –30 F. How is this constancy of body temperature maintained?

On the seasonal approach of cold winter the animals proceed to improve their heat insulation by growing better fur, feathers, or hair, and also by accumulating thicker layers of fat, by driving the blood from the surface so as to conserve its heat and to render the skin non-conducting. At the same time they accelerate their metabolic processes by producing more thyroxine, increasing muscular activity, and by consuming more "heating" feeds. They also resort to such devices as avoiding wind, seeking out the direct sunshine, and huddling together. These are but some of the ways in which cattle, sheep, and horses winter outdoors at –30 F without harm, without lowering body temperature even by 1 F. All this of course occurs at an energy cost which may depress the production of milk, meat, and so on, but the animals continue to maintain a constant body temperature.

This much cannot be said for hot weather. While good adjustment to cold weather, as indicated by constant rectal temperature, extends for a range of over 100 F, from +70 to –30 F or lower, good adjustment of cattle, sheep, and swine to hot weather is only for a few degrees. The rectal temperature in these animals begins to rise at temperatures slightly above 70 F and continues rising accompanied by serious consequences to the animals and their productive levels. Let us discuss the hot weather effects in some detail.

On the approach to hot summer, the hair and subcutaneous fat become thinner and the surface circulation becomes greater so as to facilitate heat dissipation. As the weather gets quite hot, the animals consume less feed, avoid the hot sun, seek shade, depress thyroxine production, decrease muscular and other activities.

Non-sweating species as swine keep cool with the help of mud wallows or other moisture that may be available. The moisture from the mud vaporizes and, like vaporizing sweat, keeps the skin cool. Cattle seek water pools in which they like to stand, especially if there is shade. Rats often wet themselves in hot weather with saliva.

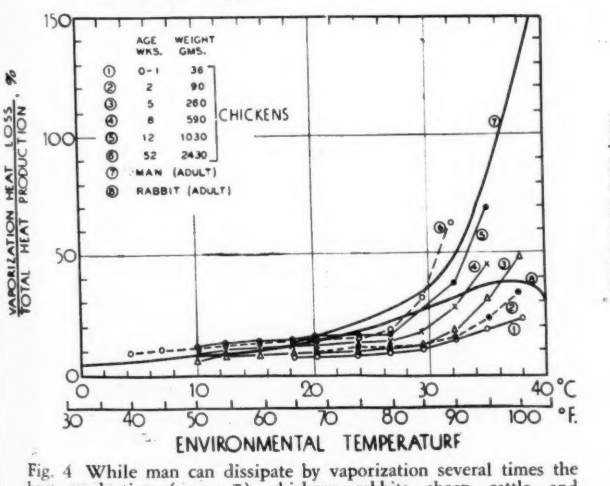


Fig. 4 While man can dissipate by vaporization several times the heat production (curve 7), chickens, rabbits, sheep, cattle, and swine dissipate by vaporization but half of the heat production; hence the much greater hot-summer distress of non-sweating species (swine, sheep, cattle) than of sweating (man, mule, ass). Curves on chickens prepared on the basis of Barrott's and Pringle's data l.c. in caption for Fig. 6. For other species see page 277 of the author's volume "Bioenergetics and Growth"

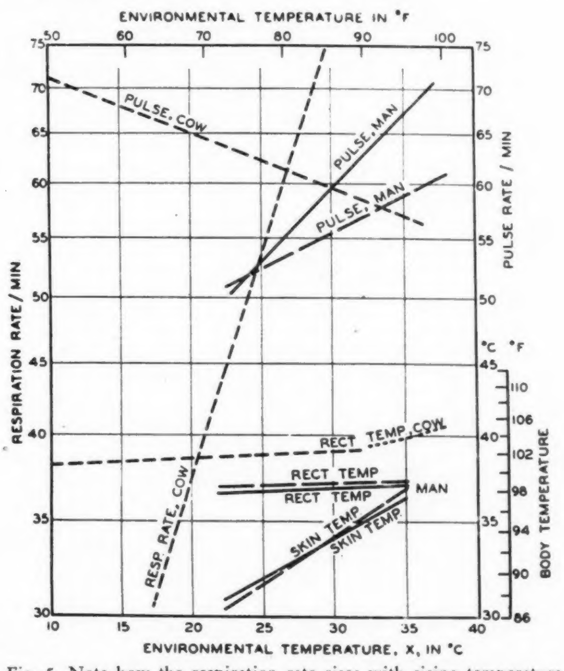


Fig. 5 Note how the respiration rate rises with rising temperature in (non-sweating) cattle, but remains constant in (sweating) man. The opposite is true for pulse rate. The chart is based on data by J. D. Hardy and E. F. DuBois (man), and W. M. Regan and G. A. Richardson (cow)

Water is the most useful natural cooling agent because it has a very high latent heat of vaporization. About 590 cal or 2340 Btu heat are dissipated when a kilogram (about 2.2 lb or 1 qt) of water vaporizes from the skin. This explains the effectiveness of mud wallows naturally used by swine. Standing or wading in water, as cattle often do, is effective because of the high heat conductivity of water; the body heat is lost about 27 times as rapidly to water as to air of the same temperature. The water is, of course, also cooler than the air.

Because of the high latent heat of vaporization of water, sweating species are able to withstand very high temperatures without harm. It was reported (E. F. Adolph and D. B. Dill, 1938) that a (sweating) hard-working man in the desert lost by vaporization some 3 qt of moisture per hour. This is equivalent to about 1800 cal or 7000 Btu per hour, which is 18 times as much heat as a resting man normally produces per hour. Most farm animals, on the other hand, can dissipate by vaporization but one-half to two-thirds of the total heat production. This is indicated in Fig. 4. While sweating species dissipate heat by vaporization from the skin *and* from the respiratory system, non-sweating ones—cattle, sheep, swine, fowls—dissipate heat by vaporization mostly from the respiratory system. There is some "osmotic" moisture given off by the skin of non-sweating species, but this is not primarily for temperature regulation. The vaporization from the respiratory system is increased by panting in hot weather as indicated in Fig. 5. But panting does not make up appreciably for the inability to sweat. Hence the distress and depression of all productive processes in non-sweating farm animals (cattle, sheep, swine, and poultry) in regions where sweating species (man, mule, ass) carry on satisfactorily. Farm animals evidently stand cold weather better than hot. This is especially true in highly productive animals, because all productive processes involve huge production of heat which is used to keep the animal comfortably warm in cold weather. It is clearly more important to devise methods for keeping animals cool in hot summers than warm in cold winters.

The Influence of Environmental Temperature on Heat Production. As outlined above, the body reacts in many different ways to changes in environmental temperature. One is by changing the rate of heat production.

The temperature zone at which heat production is lowest is called thermal zero, thermoneutrality, or comfort zone. At the comfort zone the environmental temperature is perfectly adjusted to keep the body temperature normal without the aid of the thermostatic controls described above.

The type of change in heat production varies with many circumstances. Figs. 6 and 7 show how age, body size, and environmental temperature influence heat production. The smaller and the younger the animal, the more sensitive it is to environmental changes in temperature, especially to cold. For instance it is shown in Fig. 6 that the small birds (curves 1 and 2) are much more sensitive to cold (their heat production curves rise much more steeply) than the large birds (curves 7 and 8); also that the "comfort zone" (minimal heat production) is at a higher temperature in the small birds. This statement is confirmed by Fig. 7 for mature animals of different species; the (small) mouse is much more sensitive to cold than the (large) rabbit. This is an important principle: The smaller the animal, the more surface area it has per unit weight; and since heat is lost by way of the surface, it would be expected that the small animal (with the larger surface per unit weight) would be more sensitive to cold than the large animal (with the smaller surface per unit weight).

In general, relatively large animals well covered with hair, fur, or feathers, which include most farm animals from rabbits and fowls to cattle and horses, can stand quite low temperatures without discomfort or injury (except of such naked exposed parts as teats, combs, and wattles). But small and young animals need careful protection from cold.

Heat production curves similar to those in Figs. 6 and 7 need to be worked out for all farm animals, and extended to lower temperatures.

It is questionable, however, whether it is possible to extend the curves in Figs. 6 and 7 to much higher temperatures, because while our farm animals have efficient adaptive mechanisms to low temperatures, these non-sweating species have no protective reserve against high temperatures. While a sweating species, like man, can keep the body temperature normal by profuse sweating and vaporizing at quite high

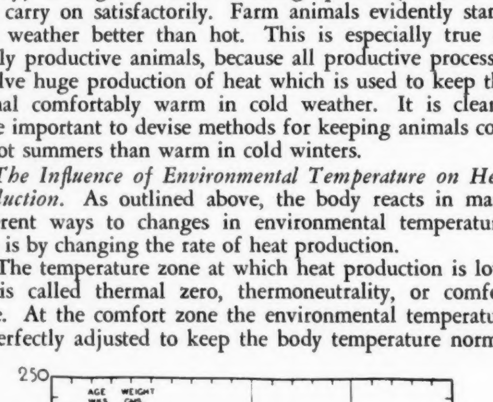


Fig. 6 Heat production in chickens of different ages and weights as function of environmental temperature (computed and plotted from data by H. G. Barrott and E. M. Pringle, J. Nut., *31*, 35, 1946). Note the flattening of the curve and the shifting of the low point with increasing body weight

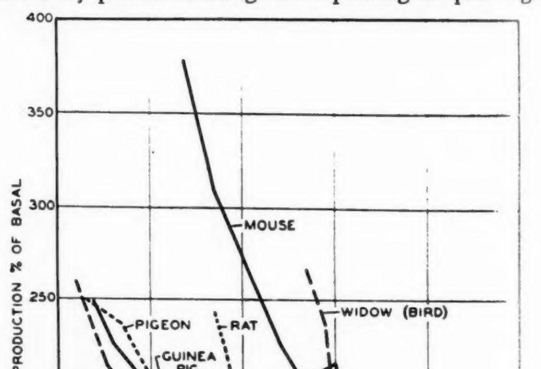


Fig. 7 The relative influence of environmental temperature on mature animals of different species and weights. Note that the large rabbit is less sensitive to cold than the small mouse—just as the small chick (curve 1) is less sensitive than the large fowl (curve 8) in Fig. 6. The curves are based on data by E. F. Terroine

temperatures, the body temperature of non-sweating species rises rapidly with increasing environmental temperature above the comfort zone; and as the body temperature rises, the heat production rises in accordance with the law of van't Hoff and Arrhenius; and as the heat production rises, the body temperature rises, and so on in a vicious circle.

It is this vicious circle that makes high temperature such a menace to non-sweating animals.

Systematic Investigations of the Influence of Temperature Factors on Farm Animals. While the effect of temperature factors has been systematically investigated on simple biochemical systems and on small organisms, this is the first plan for a systematic long-range research for large farm livestock.

It is evident that before the engineer can create the desirable "private climates" for animals, the physiologist must describe their physiologic reactions to climatic factors. J. R. McCalmont of the USDA (BPISAE) has shown the plans of a laboratory being built at Columbia for such a study (See page 472, AGRICULTURAL ENGINEERING for October, 1946.

The laboratory will have facilities for controlling dry-bulb thermometer temperature, humidity, air movement, radiations, and for measuring the metabolic processes, especially heat production. The research will begin with collecting data on heat production on cows of average size and productivity; heat dissipation (by vaporization, radiation, convection, and conduction); productivity (milk yield, change in body weight); efficiency (ratio of output to input); physiological reactions (respiration and circulation rates and volumes; rectal, surface, and subsurface temperatures). Special attention will be given to mapping of the "comfort zone" and "critical temperatures". The comfort zone is expected to shift with body size, productive level, age, and other factors.

SUMMARY AND DEFINITIONS

1 "Effective temperature" is an index of the cooling (or heating) effect of the environment. A given "effective temperature" may be obtained by different combinations of four factors: dry-bulb temperature, humidity, air movement, radiation (to or from the body).

2 The engineer's "comfort zone" coincides with the physiologist's "thermoneutrality" at which heat production is minimal.

3 Body temperature is controlled by many mechanisms, one of which is the shifting of blood to the surface or interior. Shifts in blood are associated with changes in pulse and respiration rates and skin temperature. Deviation from normal rectal temperature is critical to the animal.

4 All activities, including milk and egg production, growth, muscular activity, are associated with extra heat production which must be promptly dissipated. As heat dissipation is faciliatated by relatively low environmental effective temperature, the position of the "comfort zone" or "thermoneutrality" moves to lower temperatures with increasing levels of activity and feed consumption. On the other hand, the rates of all activities are adjusted to the effective temperature. Feeding and other activity levels tend to decline with increasing effective temperatures and increase with decreasing temperature. Hence, man and animal in hot regions tend to be "lazier" and less productive than in temperate or cool regions. The zone for maximal productivity is considerably below the "comfort zone" temperature. Its position depends not only on productive level but also on body size, age, amount of insulation (fat, fur, feather), body color, nature of neuroendocrine system, and so on. Protection from heat is often more important for productive animals than protection from cold.

5 Our purpose is to map heat production and heat dissipation, pulse and respiration rates, body temperature, and productive levels in animals of different size and productive capacities as functions of environmental dry-bulb temperature, humidity, air movement, and radiation, so as to furnish the basic physiologic data for building shelters against heat and cold as may be required to attain maximal production and profit.

Fans for Mow Hay Curing

(Continued from page 513)

the farmer wants to get the greatest volume of air against the greatest pressure so as to dry his hay as quickly as possible, he can open the aileron control and the fan will operate without tripping out the motor. Of course, it would be possible to adjust the aileron control so that the motor would not trip out when the mow is empty, and then leave the aileron control in this position at all times; however, as the mow is filled with hay, the aileron may be opened up, allowing the fan to handle the greatest volume of air that it is capable of handling with the fixed speed and given motor horsepower.

The forwardly curved blade hay-curing type ACF fan has proved most efficient and successful as evidenced by hundreds of installations which have been operating for years in mows all over the country.

What Makes the Mow Hay Drier Work?

TO THE EDITOR:

I AM interested in the answer to the above question. Our company has made a number of installations in this area, all of which have been quite successful in that the alfalfa has been properly cured, producing a product somewhat superior to the usual field-cured alfalfa.

The proper fan to use is a most intriguing subject. Some years ago we endeavored to point out the fact that the static pressures developed in the systems of the Tennessee Valley Authority and Virginia Polytechnic Institute were extremely low; in fact, even as low as 3/8 in. We could not understand how air could be blown through a mow of hay from 4 to 12 ft in depth, and we are still interested in knowing why the mow drier does work. Certainly it is not due to any fan forcing the air through the hay at the low pressures such as have been used.

From various sources we sought information pertaining to the resistance of hay to air flow, but unfortunately such data was not obtainable, so under our direction we conducted some very accurate tests at Lehigh University.

These tests were made with hay placed in a circular vessel approximately 3 ft in diameter and packed as nearly as possible to that of hay loosely placed in a mow. These tests were most accurate in every possible respect and it is therefore interesting to note that, with hay 7 ft high and very low velocities of 10 fpm, the resistance is approximately 0.6.

In connection with a practical installation which is still in operation, alfalfa is being cured in bale form, in which the hay is piled from four to six bales high and tightly placed together so that the air does not pass over the bales. That would be the normal procedure, in which case the hay would be dried by capillary attraction from the inside to the outside.

It should be obvious to anyone that no fan of any make could possibly force air through bales of hay placed in this manner, and yet, although one of our large fans is being employed for the purpose, it is our opinion that it is not the fan itself which is accomplishing the results, which, incidentally, have been most pleasing and in the past several years considerable hay or alfalfa has been dehydrated.

In another installation which we made some years ago, the hay itself was placed on the ducts directly in the field and was protected from rain and sun by means of a tarpaulin; and this dehydrator also produced quality material. This is mentioned because in some of the discussions on the subject it has been pointed out that the hay should be placed in barns with tightly sealed walls. In this case, since we have no walls, it is obvious that they were entirely unnecessary.

We are still trying to find the answer to the question: What makes the mow hay drier work?

LLOYD J. HERSH

Lehigh Fan & Blower Co.

Ground Water in Agriculture

II. GROUND WATER IN UTAH

By Ed. H. Watson

IN 1935 a ground water law was passed by the Utah state legislature. Before the passage of the law, title to ground water in this state was acquired by putting the water to beneficial use. It became necessary, therefore, for all wells that had been drilled prior to that time, and the water put to beneficial use, to be registered in the state engineer's office in order to carry out the terms of the new law. There were more than twenty thousand of them. Information required in the claim that was filed, claiming the rights to the water, covered date of priority, size and description of diverting works, and maximum use of water. Such rights that had been established by use were called diligence rights.

After the passage of the 1935 law it was provided that all future rights to ground water be initiated by the filing of an application in the state engineer's office. The information required of the applicant consists of his name and residence, accurate location of well, amount of water applied for, the period, purpose and place of use, and description of diversion works. Permission to drill a well to explore for water must be obtained from the state engineer and all well drillers must be bonded. An accurate log of the well must be furnished and any substantial change in the operation of the well, such as cleaning and repairing, or deepening, must be done under the jurisdiction of the state engineer.

The idea behind the ground water law is the control of the development and exploitation of ground water basins. When the state engineer has evidence that warrants his belief that the further drilling of wells would impair existing water rights, he may refuse to approve any more applications for ground water in the area in question.

Some effort has been made to replenish the supply of ground water by turning the early spring runoff, which would otherwise go to waste, out over the coarse gravels at the foot of our main mountain ranges. This practice is particularly applicable to the gravel terraces that lie along the Wasatch Mountain range and its extension to the southward. Here old Lake Bonneville washed the base of the mountains for long periods of time, depositing gravels and clays along its shore line as it rose and fell with the change of climate. Alluvial soils now cover these gravels which have become excellent aquifers for ground water. Such diversion of flood water, that would otherwise waste into Great Salt Lake and later be lost by evaporation, impounds it at once in underground storage where it can be used at will by those who depend on this supply for irrigation, industry or domestic use. This practice offers a wide field for development and will save much of Utah's waste water that cannot be impounded in surface reservoirs.

In order to acquire a thorough knowledge of its ground waters, the State of Utah is cooperating with the U. S. Geological Survey in procuring much valuable information. About 25 recording gauges are now maintained in various parts of the state to keep a continuous record of ground water levels. Special studies have been made in Cedar City Valley, Beryl, Flowell, and Erda districts. In Cedar City Valley the geology has been worked out and reasons discovered for the behavior of certain wells. Information collected has enabled the state engineer's office to acquire fundamental data necessary for the adjudication of ground water rights. In the Beryl district the water level has been carefully observed for several years and every change noted. It is known that the annual recharge of this area is very limited, whereas the land to be served is very extensive. A large area of good land having only limited water possibilities thus lends itself to ruthless exploitation by unscrupulous speculators. This very thing has happened and many individuals, not knowing the actual circumstances that pointed to a very limited supply of water, have been deceived into launching out on programs of agricultural development that can only end in disaster. It consequently became necessary recently to withdraw the Beryl district from further applications for ground water rights.

In the Flowell district the water users have been given the benefit of special studies by the U. S. Geological Survey, wherein individual wells that were badly leaking were studied and each owner learned how and where the leakage in his well occurred. Such information cannot be obtained by the well owner himself and is very valuable to him.

In order to save the wastage that exists in almost all ground water areas, due to leaky and uncontrolled wells, the state engineer's office has purchased a mud jack which is used in cooperation with owners of such wells to repair or control them. The mud jack is simply a pump that forces mud under pressure to all underground cavities and seals them up. The well is either put under control or finally plugged and abandoned. This program is just beginning but so far has proved very successful. Many thousands of acre-feet of water that would otherwise go to waste will now remain stored in the underground subject to use when needed.

The ground water law has been in operation in Utah for eleven years and has been operating with a reasonable degree of success. Much of the initial opposition to a once unpopular law has disappeared, and it is believed that, if the state can control the surface waste by recharging the underground and save the waste water from leaky wells by controlling or plugging them, it has rendered a service to its water users, and has amply justified the operation of the ground water law.

This paper was prepared expressly for AGRICULTURAL ENGINEERING, and is the second of a series of papers to be contributed by the Subcommittee on Ground Water of the A.E.A.E. Committee on Agricultural Hydrology.

ED. H. WATSON is the state engineer of Utah.

Treating Surface Water for Farm Use

IT IS quite possible to make surface water safe for human consumption by proper treatment. This system of surface water treatment consists of a modified "slow" sand filter with a means of properly storing and disinfecting the filtered water. The filter has been modified to meet rural needs and give maximum efficiency with the least operation. The water that comes from the properly constructed and properly operated filter is clear and sparkling and with adequate storage and disinfection will furnish sufficient quantities of good, pleasant water for drinking or any other household use.—From "A Surface Water Treatment System for the Rural Home," by Joe B. Winston, Engineering Experiment Station Bulletin 89, A. & M. College of Texas.

Forced Air Flow in Drying Hay

An Analytical Interpretation

By Rene Guillou
MEMBER A.S.A.E.

RECENT published papers on hay drying suggest that an attempt to develop a formula connecting air pressure and air flow through hay may be of interest. The present analysis was prompted in particular by data in papers by Shedd[1]* and by Hendrix[2], which afford a check on theoretical conclusions and a basis for calculating constants. Fluid flow through beds of solids and banks of tubes has been analyzed by a number of authorities. However, the results are of little value in hay drying because they involve quantities that are difficult or impossible to determine for hay. Several approaches have been used in this work. The material may be considered as a system of channels through which the fluid is flowing[3,4], or as a set of orifices[5,6], or as a collection of solids immersed in the moving fluid[7]. The latter conception appears to apply best to hay drying, especially as this type of flow has been carefully studied in the "transition" range of Reynolds numbers encountered in drying hay.

The common expression for the drag of a solid body immersed in a moving fluid may be written[8]:

$$F = c_1 (\mu / \gamma V a)^{2-n} A \gamma V^2 / 2g$$

where F is the drag (lb)

c_1 and n are dimensionless constants depending on the shape of the body and on the Reynolds number

μ and γ are the absolute viscosity (lb/ft-hr) and the density (lb/cu ft) of the fluid

A and a are the projected area (sq ft) and the effective linear dimension (ft) of the solid

V is the velocity of the fluid (ft/hr)

g is the gravitational acceleration (ft/hr²)

Any other consistent units will apply. The term in parentheses will be recogized as the reciprocal of Reynolds number.

For a body of weight W (lb) and density s (lb/cu ft), the projected area is $A = c_2 W/as$, where c_2 is a dimensionless constant depending on the shape of the body. The drag may therefore be written as:

$$F = c_1 c_2 \mu^{2-n} \gamma^{n-1} W V^n / 2 g a^{3-n} s$$

If a collection of solids occupies a considerable portion of the section available for fluid flow, the fluid velocity past it is greater than that measured for the gross section. If a column of unit section and length L (ft) contains solids of weight w (lb/sq ft), the fraction of total volume occupied by solids is (w/sL). The fraction of a plane section occupied by solids is then $(w/sL)^{2/3}$, and the fraction of a plane section available for fluid flow is $1-(w/sL)^{2/3}$. For this situation, the combined drag P (lb/sq ft) of solids of weight w in a column of unit section and length L is:

$$P = \frac{c_1 c_2 \mu^{2-n} \gamma^{n-1} w}{2 g a^{3-n} s} \left[\frac{V}{1-(w/sL)^{2/3}} \right]^n \qquad [1]$$

The expression w/sL for the fraction of the total volume occupied by solids is an average value for a quantity that is varying in a vertical column, if the material is compressible, and its use here is not strictly correct. If w_0 is the weight per unit length at the top of the column, k is a factor representing the compressibility, and dw/dL is the weight per unit length of the column at a depth L, it may be presumed that, approximately: $dw/dL = w_0 + kw$. By integration, $w = w_0 (e^{kL}-1)/k$ and $dw = w_0 e^{kL} dL$. These values may be combined with equation [1] to obtain dP/dL in terms of w and L, giving P by integration. The result is quite complicated and of doubtful value when the difficulty of determining w_0 and k is considered. As an approximation in the range of hay drying operations, dP/dL may be considered to vary simply with some power of e^{kL}, such as $e^{k'L}$. Integration then gives a variation of pressure with the function of depth $(e^{k'L}-1)/k'$, where k' is a measure of compression of the material due to the weight of the portion above.

Hendrix mentions that pressure drop in a column of hay appears in some cases to vary as a power of the depth and in some cases as an exponential function of the depth. Actually his observations appear to agree well with plots of the function $(e^{k'L}-1)/k'$ against depth L, for different values of the parameter k'. The power relationships are for k' less than 0.2, indicating only slight compression. In this region $(e^{k'L}-1)/k'$ approaches $L^{2k'}$, and appears as a straight line when plotted against L on log log paper. The exponential relationships are for k' greater than 0.3, indicating considerable compression with increasing depth. Here $(e^{k'L}-1)/k'$ approaches $e^{k'L}/k'$, and appears as a straight line when plotted against L on semilog paper. While this is an interesting explanation of the peculiar relation of pressure drop to depth, its value for design purposes seems limited by the difficulty of measuring and predicting w_0 and k'.

Returning to equation [1], this might be used for design purposes; subject to the error of considering the fraction of total volume occupied by solids to be a uniform, average value; and provided the effective shape, size, and density of the solids composing the hay were known. Estimation of these things gives pressures roughly equal to those that have been observed. However, in the absence of means of measuring separately the effective shape, size, and density of hay solids, it is desirable to combine the measure of these characteristics in a single constant. Accepted values for the drag of immersed solids place n between 1.4 and 1.7 for different geometrical shapes, with little change in the range of Reynolds numbers from 10 to 100 that are commonly involved in hay drying. The exponent determined by Hendrix and by Shedd for hay drying is the reciprocal of this one, and corresponds to values of from 1.3 to 1.7 for different lots of hay, with no change over the range of measured velocities. Apparently $n=3/2$ may be taken as a good design figure. Over the range of usual values, $1/[1-(w/sL)^{2/3}]^{3/2}$ is approximately equal to $25\,(w/sL)^2$. Making these substitutions in equation 1 gives

$$P = 25 c_1 c_2 \mu^{1/2} \gamma^{1/2} w^3 V^{3/2} / 2 g a^{3/2} s^3 L^2$$

If the ratio of volume of solids, w/s, to their air-dry weight R, is considered also as a characteristic c_3 of the solids, then $w/s = c_3 R$, and

$$P = 25 c_1 c_2 c_3 \mu^{1/2} \gamma^{1/2} R^3 V^{3/2} / 2 g a^{3/2} L^2 \qquad [2]$$

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

RENE GUILLOU is head, agricultural engineering department, University of Hawaii.

*Superscript numbers refer to the appended references.

The product of air density and viscosity varies but little over the range of hay drying conditions, so that the value of $25c_1c_2c_3\mu^{1/2}\gamma^{1/2}/2ga^{3/2}$ may be considered to be a characteristic of the solids composing the hay, and of the units used. Choosing convenient units, we may write

$$p=CR^3v^{3/2}/L^2 \qquad [3]$$

in which

- p is the pressure drop in inches of water
- R is the air-dry (20 per cent moisture) weight of hay in pounds per square-foot of floor surface
- v is the air velocity for the gross section in feet per minute
- L is the depth of the hay in feet
- C is a constant depending on these units and on the shape, size, and relation of volume to air-dry weight of the solids

This simplification evidently fails for L very large or very small in relation to R, in other words, for hay much looser or more compact than is usual. The loss of generality appears to be justified, however, by the usable simplicity of the expression.

TABLE 1. CONSTANT C IN THE EXPRESSION $p=CR^3v^{3/2}L^2$ AS DETERMINED FROM THE OBSERVATIONS OF HENDRIX AND SHEDD

Air-dry weight (20% moisture) R lb per sq ft	Moisture per cent	Depth L ft	$p/v^{3/2}$ inches of water per $(ft/min)^{3/2}$	Constant C
Alfalfa ¼, brome ¾ (Shedd 6-20)				
38	30	8	.0039	$5x10^{-6}$
38	Air-dry	7	.0052	$5x10^{-6}$
Alfalfa (Shedd 8-14)				
43	30	8¼	.0055	$5x10^{-6}$
43	Air-dry	7¾	.0062	$5x10^{-6}$
Alfalfa 51%, grass 29%, wheels 21% (Hendrix 1-45)				
31	60	8	.0061	$13x10^{-6}$
31	20	6	.0088	$11x10^{-6}$
Alfalfa, ½ bloom, ½ pod (Hendrix 3-45)				
43	48	10	.0056	$7x10^{-6}$
43	21	7½	.0068	$5x10^{-6}$
Alfalfa, bale slices (Hendrix 5-45)				
41	43	8	.0072	$7x10^{-6}$
38	22	6½	.0066	$5x10^{-6}$
Alfalfa, prebloom, 1½" cut (Hendrix 6-45)				
62	41	9	.0160	$5x10^{-6}$
62	18	7	.0280	$5x10^{-6}$

Table 1 shows values of C calculated from the observations of Shedd and Hendrix. The results for alfalfa green and dry, in bale flakes, loose, or chopped, seem quite consistent. For one lot of mixed hay, C is about twice as large as for pure alfalfa, corresponding to solids less dense by a factor of $1/2^{1/3}$, or 0.8, which seems reasonable. The constant for brome appears to be about the same as for alfalfa. In general, C should vary with the cube of the ratio of the volume of the solids to their air-dry weight, and inversely with the three-halves power of the effective linear dimension of the solids. In other words, C should be large for light, fine solids; and small for dense, coarse solids.

The practical implications of these expressions are of interest. Apparently air pressure should increase with the three-halves power of the velocity, directly with the weight per unit of floor space if the density is constant, and approximately with the square of the weight per unit of mow volume. Piling twice as much hay on a unit of floor space should multiply by 5½ the pressure and power required to maintain a given air flow per ton of hay, even if the heavier loading does not compress the hay. Compression of the same floor loading to two-thirds of its former depth by chopping, baling, or otherwise, should double or triple the pressure and power to maintain the same air flow per ton of hay. If baled hay is piled to the same height as loose hay it may take from six to ten or more times as much pressure and power to supply it with a given air rate per ton. This is not to say that hay should not be piled high or baled before drying, but merely that the effects on pressure and power requirements should be taken into account. The importance of even distribution in the mow is also emphasized. If two columns of the same hay are of equal height and subjected to the same air pressure from beneath, one containing a fourth more material than the other should receive about half as much air per pound of hay.

In view of the limited range of observations available for testing them, all of these conclusions are to be taken as tentative. It seems, however, that considering the probable drastic effect of compression and depth of piling on power requirements, a more definite knowledge of the relationships involved is essential to intelligent design.

REFERENCES

1 Shedd. AGRICULTURAL ENGINEERING. 27, 169: 1946.
2 Hendrix. AGRICULTURAL ENGINEERING. 27, 209: 1946.
3 Colburn, Chilton, and King. Trans. Amer. Inst. Chem. Engrs. 26, 166: 1931.
4 Perry. Chemical Engineers Handbook. McGraw-Hill Book Co.
5 Walker, Lewis, McAdams and Gilliland. Principles of Chemical Engineering. McGraw-Hill Book Co.
6 Grimison. Trans. Amer. Soc. Mech. Engrs. 59, 583: 1937.
7 Bakhmeteff and Feodoroff. Journal of Applied Mechanics. 4, A-97: 1937.
8 Dodge and Thompson. Fluid Mechanics. McGraw-Hill Book Co.

Two views of a Link-Belt trench hoe with a ½ cu yd bucket, powered by a Caterpillar diesel engine, being used for digging irrigation and drainage ditches by Heringer & Co. of Rio Vista, Calif. This machine has been averaging approximately 400 ft of 3½-ft ditch an hour, or 250 ft of 6-ft ditch per hour

Ground Water for Irrigation in Georgia

By S. M. Herrick

ALTHOUGH the climate of Georgia is humid, periods of temporary rainfall deficiency occur locally almost every year. Because of these deficiencies there appears to be a need for irrigation. Although surface water may be more applicable to irrigation problems in certain sections of the state, this report has been arbitrarily limited to ground water.

This work has been done by the Geological Survey, U. S. Department of the Interior, in cooperation with the Georgia Department of Mines, Mining and Geology, Garland Peyton, director. The author thanks O. E. Meinzer, geologist in charge of the ground water division of the U. S. Geological Survey, under whose direction this work has been done.

Geologic Conditions. The occurrence of ground water depends upon the character and structure of the water-bearing rocks. The "Fall Line" or "Fall Zone" which passes through Augusta, Macon, and Columbus, forms the boundary between two large ground-water provinces in Georgia, the Coastal Plain and the Piedmont provinces. The formations underlying the Coastal Plain are stratified rocks consisting largely of sands, clays, and limestones. These strata are inclined toward the south and occur in an alternating succession of permeable sands or limestones, and relatively impermeable clay beds. Water which falls on the outcrop areas of the permeable beds moves down the dip and becomes confined under artesian pressure. These conditions are illustrated in Fig. 1. Because of these conditions, artesian water is present in central and south Georgia. The shallow formations contain water under water-table conditions.

North of the Fall Line, the greater part of the area is underlain by crystalline rocks in which the ground water generally occurs under water-table conditions either in fractures in the rock or in the overlying unconsolidated mantle rock which is a product of the weathering and disintegration of the hard rock. An example of these conditions is shown in Fig. 2. Eight counties in the north part of state lie in the Appalachian province and are underlain by sedimentary rocks consisting of well-consolidated shales, sandstones, limestones, dolomites and cherts, largely of Paleozoic Age. These rocks, with few exceptions, are low in permeability, and ground water in them occurs in solution cavities and under conditions similar to those in crystalline rocks.

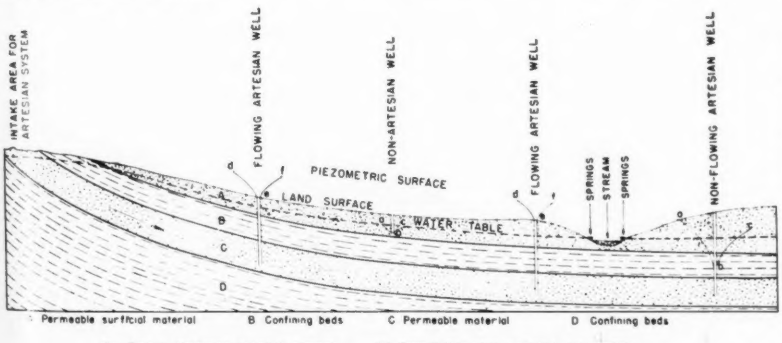
S. M. HERRICK is connected with the Geological Survey, U. S. Department of the Interior.

Available Ground-Water Supplies. The problem of determining the quantity of ground water that is available for irrigation in any part of Georgia is summarized in the question of how many acres of tillable land may be irrigated each year over a period of indefinite duration without ultimately exhausting available ground-water supplies. The answer to this important question involves several highly technical problems which must ultimately be worked out by means of hydrological tests in the field. Except for one important aquifer, the Ocala[1] limestone, such data have not yet been obtained for the state of Georgia as a whole. However, an approximate answer to this problem may be gained by examining well records containing pumpage yields of the different types of wells now being used throughout the state.

Dug wells furnish water for a large part of the rural population of Georgia. Wells of this type are generally limited to the surficial residuum and obtain water from such material. They commonly range in depth from 15 to 90 ft and have an average diameter of 3½ to 4 ft. During dry seasons the water table may decline to a level below the bottom of the well, and under these conditions of course the well becomes dry.

In the Piedmont and Paleozoic areas, drilled wells penetrate the underlying bed rock and obtain water from the fractures existing in the rock. The presence or absence of these fractures determines the capacities of these wells. The drilled wells range in diameter from 5 to 12 in and in depth from about 50 to as much as 1,000 ft. The yields range from a few gallons a minute to as much as 100 gpm, the average yield being around 10 gpm. In the Paleozoic area drilled wells range from 5 to 10 in in diameter and from about 30 to 500 ft in depth. The wells on which records have been obtained yield from a few gallons a minute to as much as 150 gpm, with an average of about 17 gpm. Drilled wells in these two provinces obtain water under water-table conditions and are subject to seasonal fluctuations like those of dug wells, but because they are usually deeper the fluctuations are not as great. A dug well, for example, may show as much as 8 ft of annual fluctuation in

[1]M. A. Warren, Artesian Water in Southeastern Georgia. Ga. Dept. Mines, Mining and Geology, Bulletin 49, 1944. Coefficients of transmissibility and storage for the Ocala formation in the Savannah, Brunswick, and St. Mary's areas have been determined and applied to ground-water conditions in these three areas.



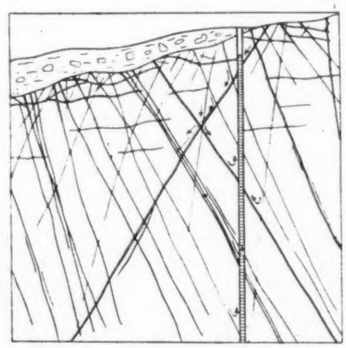


Fig. 1 *(Left)* This diagram shows how water moves down a dip in stratified rocks and becomes confined under artesian pressure • Fig. 2 *(Right)* This diagram shows conditions in an area underlain by crystalline rocks, in which the ground water generally occurs under water-table conditions

water level as compared with 4 ft in a drilled well. Records on drilled wells in the Piedmont show for many of these wells a progressive decline in yield over a period of years. For example, in 1911 a well owned by the city of East Point produced 340 gpm, but in 1943 this yield had dropped to 175 gpm, apparently due to local depletion of the ground-water supply.

Drilled wells in the Coastal Plain range in diameter from 3 to 24 in and in depth from 90 to 1,000 ft. Yields range from 5 to 2,000 gpm. The artesian wells have small seasonal fluctuations in water level except near recharge areas where the fluctuations may be as large as those of water-table wells. The Geological Survey, U. S. Department of the Interior, publishes annually a series of water-supply papers which contain records of fluctuations of artesian pressure in key observation wells in this part of the state. On the basis of available data the conclusion is reached that ground-water supplies may be obtained from drilled wells in any part of the Coastal Plain.

In Georgia, springs are numerous and of many different kinds. Most springs show seasonal fluctuation and their flow is affected by topographic location and geologic conditions. For example, hillside springs tend to become completely dry during periods of drought, while those situated in valley bottoms continue to flow throughout the year, often with little diminution in the amount of total flow. Topographic location of springs is of greater importance in the Piedmont area than in either the Paleozoic or Coastal Plain provinces. In the latter two provinces geologic conditions constitute the chief controlling factor, with the result that formation differences determine the location of springs and the amount of flow. The yield of springs in Georgia ranges from small seepages up to as much as 7,200 gpm. However, the large majority of springs are small and therefore of little consequence as sources of water for irrigation. In the case of large perennially flowing springs location and availability of supplies in relation to land that is to be irrigated constitute the chief problem.

Requirements of Supplemental Irrigation. In order to apply data on available ground-water supplies to the problem of irrigation the requirements of supplemental irrigation must be known. It has been found[2] that water applied over an area to a depth of 1 in per week will satisfy most irrigational requirements in regions having a humid climate. This amount of water is equivalent to 27,152 gal per week per acre, or about 7½ gpm, pumping 10 hr a day for a six-day week. Because irrigation is seasonal and little required in wet years, periods of replenishment occur and there is less danger of eventual depletion. Nevertheless, other and more important uses of available ground-water supplies — public, domestic, and industrial — must be considered.

Considering the uses of ground water in relation to available supplies, the conclusion is reached that irrigation of small acreages only seems feasible north of the Fall Line. However, in the Coastal Plain large quantities of ground water are available.

Quality of Water. With few exceptions the ground waters in Georgia are suitable for irrigating all types of farm crops. The available data indicate that the concentration of dissolved mineral matter is usually relatively low and seldom exceeds 300 parts per million. In general, ground waters in the crystalline rocks contain less dissolved matter than waters in the sedimentary rocks.

Waters in which the dissolved mineral constituents consist primarily of sodium salts may be harmful to crops under certain conditions. In the arid and semiarid regions of the west it has been found that waters containing large proportions of sodium salts may injure some crops and also adversely affect the texture of the soil unless adequate drainage is provided. In the humid climate of Georgia where frequent rainfall would tend to leach out any accumulation of mineral salts, it is unlikely that the ordinary ground waters would present any difficulty.

Some of the deep ground waters in the Coastal Plain of Georgia are known to contain larger proportions of sodium than of other basic constituents. However, of more than 170 samples of ground waters for which analyses are given in Geological Survey Water Supply Paper 314, "Underground Waters of the Coastal Plain of Georgia", less than 10 contained larger proportions of sodium than would be acceptable for irrigation in arid regions. Waters from these few wells might even be used in a humid climate without noticeable damage to crops.

Ground waters contaminated with sea water or other brines and those polluted with large quantities of certain industrial waters should not be used for irrigation. In general, however, it is believed that from the standpoint of chemical quality most of ground waters in Georgia are suitable for irrigation.

[2]G. A. Mitchell and F. E. Staebner. 1927. Spray Irrigation in the Eastern States. U. S. Dept. of Agriculture, Farmers' Bulletin No. 1529, pp. 5.

REFERENCES

Bowie, Jr., A. J.
1906. Irrigation in the North Atlantic States. U. S. Dept. Agriculture, Bull. 167.

Engler, K., Thompson, D. G., and Kazmann, R. G.
1945. Ground Water Supplies for Rice Irrigation in the Grand Prairie Region. Arkansas. Agric. Exp. Sta., Univ. Kansas. Bull. 457.

Kazmann, R. G.
1944. Some Field Applications of Water Transmissibility and Storage Coefficients. Agric. Engineering, August, 1944.

LaForge, L., Cooke, W., Keith, A., and Campbell, M. R.
1925. Physical Geography of Georgia. Geol. Survey Ga., Bull. 42.

Lamar, W. L.
1942. Industrial Quality of Public Water Supplies in Georgia, 1940. U.S.G.S., W.S.P., No. 912.
1942. Chemical Character of the Larger Public Water Supplies in Georgia. Journ. Americ. W. W. Assoc., Vol. 34, No. 4.

Lewis, M. R.
1943. Practical Irrigation. U.S. Dept. Agriculture, Farmer's Bull. No. 1922.

McCallie, S. W.
1908. Underground Waters of Georgia. Geol. Survey Ga., Bull. 15.

Meinzer, O. E.
1923. The Occurrence of Ground Water in the United States. U.S.G.S., W.S.P., No. 489.

Mitchell, S. A. and Staebner, F. E.
1927. Spray Irrigation in the Eastern States. U.S. Dept. Agriculture, Farmer's Bull. No. 1529.

Roe, H. B. and Park, J. K.
1941. Supplemental Irrigation. U.S. Dept. Agriculture, Univ. Minnesota, Extension Bull. No. 225.

Staebner, F. E.
1940. Supplemental Irrigation. U.S. Dept. Agriculture, Farmer's Bull. No. 1846.

Stanley, F. W.
1917. Surface Irrigation for Eastern Farms. U. S. Dept. Agriculture, Farmer's Bull. No. 899.

Stephenson, L. W. and Veatch, J. O.
1915. Underground Waters of the Coastal Plain of Georgia. U.S.G.S., WSP., No. 341.

Warren, M. A.
1944. Artesian Water in Southeastern Georgia. Geol. Survey Ga., Bull. 49.

Williams, M. B.
1911. Possibilities and Need of Supplemental Irrigation in the Humid Regions. Yearbook of U.S. Dept. Agriculture for 1911.

A Point in Management of Scientific Personnel

By D. B. Krimgold
MEMBER A.S.A.E.

A BORE has been defined as one who elaborates on the obvious. I shall not run the risk of qualifying by elaborating on the now accepted axiom that of all the assets a nation or any other organization may have the human resources are by far the most valuable. I would like to say, however, that this applies to the greatest degree in case of technical and scientific personnel.

The scientist or professional worker joins an organization (public or private) at the "junior" level — he grows in his job. The longer he is employed, the more society (through public or private agencies) has invested in him and the more valuable his services become. A young technician or scientist, if he is to develop properly, must be given expert tutelage and guidance by one who has reached "maturity" in his line of work. He must work in close contact with technicians and scientists and must not be left entirely on his own to repeat mistakes which have been made many times before him at considerable loss of funds and of valuable time. This is pretty generally recognized and is, by and large, being given proper consideration.

The point I would like to make concerns the maximum utilization of the scientific research worker after he has reached "maturity." The general tendency is to leave such workers alone and to divorce them from administrative duties as much as possible. The administrator usually feels that he has done well if he has freed such workers from routine administrative duties. However, he cannot and does not deprive his agency of the advice and consultation of such workers who, through their several years of work, have become outstanding specialists in their fields. Such use of scientific personnel is highly beneficial and should be practiced more widely. It must, however, be fully realized that the more these men are utilized in such capacity, the less time they have to pursue their special studies and investigations.

Even when the demand on his time for consultation and advice is limited, the scientist, when working alone, can follow up and develop only a rather small proportion of the valuable ideas which may occur to him in the course of his work.

More often than not an idea or project proposed by a scientific worker is not approved or encouraged because funds may not be available or because the idea may be so far advanced that its significance cannot be fully grasped by boards of directors, legislators, or even by research administrators who cannot be highly specialized in all the fields they must supervise. Such ideas are seldom published and are usually dumped in the rubbish when the scientist leaves his post.

The conditions described are real. They exist in public agencies, private institutions and in large corporations. If these defects could be remedied, the individual agencies, and through them society as a whole, would derive untold benefits.

It is my purpose to propose a possible partial remedy for the consideration of those charged with the management of scientific personnel. Before doing so I would like to reinforce my argument by the following quotation from "The Autonomy of Science," by M. Polanyi, reprinted in the "Scientific Monthly" for February, 1945:

> "All the time the scientist is constantly collecting, developing and revising a set of half-conscious surmises, an assortment of private clues, which are his confidential guides to the mastery of his subject. This loose system of intuitions cannot be formulated in definite terms. It represents a personal outlook which can be transmitted only–and only very imperfectly–to personal collaborators who can watch its daily application for a year or two to the current problems of the laboratory. This outlook is as much emotional as it is intellectual. Expectations which it entertains are not idle guesses but active hopes filled with enthusiasm."

My remedy is very simple and easy to achieve; it consists of the following: Every scientific worker after having reached "maturity" in his work should be assigned one or more assistants. Such assistants should preferably be picked by the scientist himself from among recent graduates of accredited schools. They should not be assigned duties by anyone other than the scientist himself, who should have the utmost freedom in dealing with his assistants. In fact, the relations between these young assistants and the scientist should as much as possible be those of the "apprentice" and the "master" of yore, provided, of course, that the working conditions and rates of pay of these assistants are such that will promote their well-being and will offer sufficient inducement for their best efforts. Such assistants through close personal collaboration with their "master and teacher" will make it possible for the scientist to accomplish a good deal more than he could alone. A young man with adequate scientific training and an abundance of energy and enthusiasm may even stimulate his "master" to greater efforts and accomplishments. Valuable advanced ideas of the older scientist which could not be tested or even published during his lifetime could be kept alive by an alert assistant and put to use some years hence when the meaning of these ideas and need for them become more readily apparent. Under such a scheme the apprentice becomes a "master" in his own right as soon as he matures and is in turn given one or more assistants. His place at the side of his old "master" is filled repeatedly by new apprentices. The effectiveness of the scientist is thus greatly increased and his knowledge, valuable ideas, and, what is more important, his "intuitions" are imparted to a large number of younger scientists who will carry on after he is gone.

Research and Democracy

WE have discovered more truth than we know what to do with, because the achievements of men of genius sometimes fail to keep just proportion. Physical science outstrips social science. And the accomplishments of both place strains on Man as a moral being which he is unable to resist. But the solution of this difficulty is certainly not to place a moratorium on science. You dare not do that, because you dare not attempt to suppress the spirit of free inquiry; you dare not attempt to put hobbles and blinders on Man which will have the effect of frustrating him in the expression of precisely those qualities which are among the most admirable he has.

I believe scientific research is a National responsibility, in that the well-being of the country is in part dependent upon it; dependent upon it because of the tangible and practical benefits to agriculture and business which it can create; dependent upon it because it demands from all the people the kind of character and belief which are the essence of democracy — honesty, tolerance, love of freedom. It is because of these considerations that the whole country is involved; and it is because of these considerations that the Universities must support it. On that basis we can give our educational program a worth and a dignity which otherwise it could not have.—From "Research as a National Responsibility" by A. W. Trueman, in "Agricultural Institute Review," July 1946.

NEWS SECTION

A.S.A.E. Fall Meeting Program

THE Fall Meeting of the American Society of Agricultural Engineers will be held at the Stevens Hotel, Chicago, December 16, 17, and 18, with three of the Society's divisions — Power and Machinery, Rural Electric, and Farm Structures — furnishing especially attractive programs over the three-day period. Immediately following the Fall Meeting, December 19 and 20, the Society will sponsor the 3rd Barn Hay-Curing Conference — also at the Stevens Hotel — the program for which will be found in another item on page 526.

Following meetings of the Society's Council, Cabinet, and Jury of Awards on December 15, the meeting proper will open Monday forenoon, with a Rural Electric program, in the nature of a symposium, on engineering problems in the distribution of electric power to farms. Contributions will include discussion of single and three-phase rural power line distribution, by Lee Moore, of REA; economics of farm service, by A. H. Hemker, rural electrification engineer, General Electric Co.; and the farm power rate, by A. E. Anderson, Commonwealth and Southern Corp.

Concurrently with this program there will be a conference on agricultural engineering research as related to the Flannegan-Hope research bill. This conference is being sponsored by the Society's College Division.

Two concurrent programs will be offered the afternoon of Monday, December 16 — Farm Structures and Rural Electric. The Farm Structures program will be a symposium on farm housing. The first speaker on this program is Cameron Hervey, associate editor of "Farm Journal," who will tell what people want, based on an extensive survey. H. E. Wichers, Kansas State College, will present the results of his farm housing experiments; Ruby M. Loper, New York State College of Home Economics, will discuss the problem of adjusting farmhouse wants to ability to pay, and Keith Hinchcliffe, University of Illinois, will talk on the design and remodeling of farm homes.

The Rural Electric program for this period will feature three subjects: B. G. Perkins of the Doane Agricultural Service will give an analysis of costs vs. returns on farm electrical equipment; J. P. Ditchman of General Electric Co., will tell how farmstead lighting can improve farm management, and Miss Lenore E. Sater, head, housing and household equipment division, Bureau of Human Nutrition and Home Economics, USDA, will report on the economics of farm freezers.

During the forenoon of Tuesday, December 17, there will be two concurrent programs — Power and Machinery and Rural Electric. The Power and Machinery program will open with a paper by J. O. Almen, head, mechanical engineering department, General Motors Research Laboratory, on the effect of residual stresses on the fatigue strength of machine parts. The second number on this program will be a paper by Sherman C. Heth, engineer in charge of the main works of J. I. Case Co., on the use of strain gauges for farm equipment design.

The Rural Electric program will open with a paper on forced ventilation of dairy stables and poultry houses by T. E. Hienton, head of the new USDA Division of Farm Electrification. Other papers will include one on electric milk pasteurizers for farm dairies by J. P. Schaenzer of REA, on parlor milking by Charles H. Wilson of Babson Bros. Milker Co., on electric motors and controls for farm applications by B. P. Hess of Westinghouse Electric Corp., and on electric steam accumulators for farm use, by J. Weston Hicks, Wesix Electric Heater Co.

The afternoon period of December 17 will be devoted to two concurrent programs, one on Power and Machinery, the other on Farm Structures. The first number on the Power and Machinery program is a paper on precision planting equipment by Roy Bainer of the University of California, which will be discussed by C. E. Guelle of International Harvester Co. Frank Irons, A. H. Glaves, and Dr. C. H. Batchelder, USDA, will discuss various phases of the subject "Equipment for Controlling Plant Insects and Diseases."

The Farm Structures program for this period will feature a symposium on farm work simplification, which will be opened by a paper on farmstead arrangements by K. B. Huff, University of Missouri, followed by a talk on swine simplification methods by Dr. Lowell S. Hardin, assistant director of the National Farm Work Simplification project, the results of a study by G. B. Perkins of the Doane Agricultural Service on the *(Continued on page 526)*

A.S.A.E. Meetings Calendar

December 16 to 18 — FALL MEETING, Stevens Hotel, Chicago.

December 19 and 20 — 3rd Barn Hay-Curing Conference, Stevens Hotel, Chicago.

January 15 to 17 — Southeast Section, Buena Vista Hotel, Biloxi, Miss.

This picture shows part of the group of 150 college instructors in agricultural engineering from 42 states of the United States and 6 provinces of Canada in attendance at the Agricultural Engineering Teaching Seminar at Purdue University, August 30 to September 4, 1946

NEWS SECTION

(Continued from page 524)

simplification in beef cattle production, and simplification in dairy production by P. R. Hoff, extension agricultural engineer, New York State College of Agriculture.

Two concurrent programs—Power and Machinery and Farm Structures—will be presented on the forenoon of Wednesday, December 18. The Power and Machinery program will open with a talk on a new plow design for deeper plowing by R. J. Altgelt of The Oliver Corp., supported by discussions based on field tests made by agricultural engineers and agronomists of several agricultural experiment stations. George Krieger, chairman of the Agricultural Development Committee of the American Petroleum Institute, will discuss his committee's program on behalf of agriculture, and there will also be a report on progress toward standardization of hydraulic controls for farm machines.

The Farm Structures program for this period will open with a paper by Dr. Samuel Brody of the University of Missouri on the reaction of different types of animals to changes in environment. Other numbers on this program will include a report of a research project at the University of Minnesota on farm building insulation, by H. B. White of the division of agricultural engineering at the University, and A. R. Schwantes, agricultural engineer, Insulite Div., M & O Paper Co.; and a presentation on plywood silo construction by J. D. Long of the Douglas Fir Plywood Assn.

There will be concurrent Power and Machinery and Rural Electric programs for the afternoon of Wednesday, December 18. The former will be in the nature of a symposium on hay handling equipment, with C. B. Richey of Harry Ferguson, Inc., discussing the buckrake, and Paul A. Whisler of Allis-Chalmers Mfg. Co. talking on the field harvester. O. F. Scholl and R. R. Raney of International Harvester Co., will discuss the twine-type field pickup baler, and F. D. Jones, Dain Mfg. Co., will discuss the wire baler. F. W. Duffee of the University of Wisconsin will talk on some new developments in unloading equipment, and R. C. Shipman of Cooperative G.L.F. Farm Supplies, Inc., will discuss equipment for mow distribution of chopped and baled hay.

The Rural Electric program for this period will feature a paper on a rural electrification extension program by F. M. Hunter of Mississippi State College, a discussion on farm electrification radio programs by D. E. Wiant of Michigan State College, and J. L. Calhoun of the Virginia Farm Electrification Council will discuss state-wide cooperative methods on rural electrification publications. George Kable, editor of "Electricity on the Farm," will tell how to prepare news stories on farm electrification, and George E. Mullin, manager of farm sales of the appliance and merchandise department of General Electric, will discuss how to reach the farm market.

A.S.A.E. Barn Hay-Curing Conference

THE 3rd Barn Hay-Curing Conference to be sponsored by the American Society of Agricultural Engineers, will be held December 19 and 20, immediately following the Society's Fall Meeting at the Stevens Hotel, Chicago. All sessions of the conference will be held in the Tower Ballrooms.

The first session, on Thursday forenoon, December 19, will be opened by E. W. Hamilton, chairman of the Society's Committee on Hay Harvesting and Storage, who will introduce Dr. Mark L. Nichols, president of the Society, who will discuss the challenge to agricultural engineers represented by problems in the field of hay curing. Following Dr. Nichols, the subject "Quality Hay Defined, in Relation to Human and Animal Nutrition" will be discussed by C. B. Bender, research specialist in dairy husbandry of the New Jersey Agricultural Experiment Station. He will be followed by Dr. Ralph E. Hodgson, assistant chief, USDA Bureau of Dairy Industry, who will report results of his research work in feeding forage harvested and preserved as silage, field-cured hay, and mow-cured hay. L. G. Schoenleber, USDA associate agricultural engineer, will discuss the effect of high and low moisture contents on drying requirements and nutrient losses in chopped forage dried in mow hay finishers. The session will close with a discussion of the terminology used in hay curing by H. D. Bruhn of the University of Wisconsin.

The afternoon program of Thursday, December 19, will be devoted exclusively to a symposium on engineering factors in hay curing and will deal with long, chopped, and baled hay. The contributions to this symposium will be presented by agricultural engineers who have been conducting hay-curing research this past season and who will report the results of their work.

The evening of December 19 will be devoted to a series of motion pictures giving views and previews of modern hay handling equipment from the standing crop to final curing and storage. C. B. Richey, past-chairman, Committee on Hay Handling and Storage, will preside.

The last session of the Barn Hay-Curing Conference on Friday forenoon, December 20, will open with a report of a special committee which will meet during the evening preceding for the purpose of boiling down the findings of agricultural engineers engaged in research in this field, which findings will be offered as the basis for recommended practice in barn hay curing. F. W. Duffee will present the report. The second number on this program will be a paper by P. T. Montfort, A. & M. College of Texas, on the use of supplemental heat in barn hay curing, which will be followed with a paper on hay density in relation to various factors, by G. E. Zerfoss, of TVA; and one on dry matter loss in hay making due to bacterial action, by Dr. Harry Miller, research engineer, University of Nebraska. *(News continued on page 528)*

This picture shows the group attending the farm structures refresher course offered by the agricultural engineering department of the University of Illinois, June 17 to 21. Reading from left to right: *First row*—H. H. Middlekamp, P. B. Potter, G. D. Kite, J. L. Copeman, Morel Leonard, G. G. Connor, C. H. Christopherson, R. R. McBeth; *second row*—G. P. Grieve, W. H. Dickerson, Jr., J. S. Boyd, M. L. Esmay, L. W. Neubauer, R. R. Parks, R. W. Whitaker, D. G. Carter; *third row*—J. B. Caton, G. E. Bowsher, C. O. Bolin, Ortie LaVoy, K. H. Hinchcliff, J. M. Anderson, E. B. Wilson, D. L. Hitch, R. N. Hovey, E. A. Olsen, E. L. Smith, Mr. Gilbert, W. A. Dennin, L. J. Smith, W. R. French; *fourth row*—N. H. Rich, C. G. Burress, Kent Richey, D. I. Cronkhite, K. W. Snyder, Ralph Ricketts, C. G. E. Downing, G. L. Nelson, R. E. McKnight, J. M. Fore, W. T. Graham, W. J. Kalmeyer, E. W. Lehmann; *fifth row*—Miss Lillian Castell, D. B. Poor, H. A. C. McGrath, W. E. Hudson, H. K. Lange

Canadian Group Attending Agricultural Engineering Teaching Seminar at Purdue University, August 30 to September 4. *Reading left to right:* J. R. W. Young, University of British Columbia; B. T. Stephanson, University of Alberta; C. J. Simpson, University of Saskatchewan; [illegible] Johnson, University of Saskatchewan; Evan A. Hardy, University of Saskatchewan; H. A. Lewis, University of Saskatchewan; C. G. E. Downing, Ontario Agricultural College; H. W. Kitching, Ontario Agricultural College; E. G. Webb, Ontario Agricultural College; J. H. Cooper, Macdonald College; Angus Banting, Nova Scotia College of Agriculture.

NEWS SECTION

(Continued from page 526)

Southeast Section Meets in January

THE executive committee of the Southeast Section of the American Society of Agricultural Engineers announces that its next meeting will be held in conjunction with the annual convention of the Association of Southern Agricultural Workers, which will be held at the Buena Vista Hotel, Biloxi, Mississippi, in January.

The Southeast Section meeting will open on January 1[illegible], a day in advance of the opening of the A.S.A.W. convention. The forenoon session will be devoted to a general program; two concurrent sessions are scheduled for the afternoon of the same day.

On January 15, there will be two joint sessions during the forenoon, one with the Horticulture Section and the other with the Agronomy Section of the A.S.A.W. In the afternoon there will be a joint session with the Home Economics Section of A.S.A.W., and concurrently with the section is arranging a program of its own featuring subjects in the fields of farm machinery and soil and water conservation.

A general session of the A.S.A.E. Southeast Section will be held on the forenoon of January 16, which will bring its meeting to a close.

Rodgers Heads Oregon Department

THE new head of the agricultural engineering department at Oregon State College is Jefferson B. Rodgers, according to announcement received from F. E. Price, assistant dean of agriculture of that institution.

Until recently Mr. Rodgers was chief engineer of War Hemp Industries, Inc. He is a graduate of the University of Idaho and has a bachelor's degree in both mechanical and agricultural engineering, and a professional degree in agricultural engineering. In his new position, Mr. Rodgers will be in charge of resident instruction and research work in agricultural engineering.

Ohio Has New A-E Experimental Farm

A NEW experimental farm to be operated by the department of agricultural engineering of the College of Agriculture, Ohio State University, and the Ohio Agricultural Experiment Station will be established near Columbus, Ohio, as a result of plans recently completed by H. F. Sinclair, president, Sinclair Refining Company; Edmund Secrest, director, Ohio Agricultural Experiment Station, and John F. Cunningham, dean, College of Agriculture. The farm will include a modern dwelling for resident supervisor, service buildings, garage, and shops. The project is conveniently located at the city limits of Columbus, near the facilities of the college of agriculture.

The program will include a study of the effect that variations in depth and spacing of drain tile will have on water in the soil and on soil temperatures in the spring; a study of timeliness in tillage, planting and harvesting operations, and related yield and quality of various crops. A study of power and labor requirements in crop production is also planned.

Drainage Conference

A DRAINAGE Conference sponsored by the Mason City Brick and Tile Co., is to be held at Mason City, Iowa, November 25 and 26. The program will be similar in nature to that of the conference sponsored by the Company last year. Drainage men from the agricultural schools of Iowa, Wisconsin and Minnesota are scheduled to present topics aimed to be of interest to drainage engineers, contractors, machinery manufacturers and others concerned with any phase of farm drainage.

A display of tile trenching machines is scheduled in connection with the conference.

Readers of AGRICULTURAL ENGINEERING are invited to attend. Due to the hotel situation, reservations should be made in advance with the Hanford Hotel at Mason City.

Personals of A.S.A.E. Members

Hatto M. Berg is now working as agricultural engineer with the U. S. Soil Conservation Service at Raymondville, Texas, having been transferred by the Service from Beeville, Texas.

Emmett R. Holekamp, who served as an officer in the U. S. Army Corps of Engineers during the war, is now instructor in agricultural engineering at the University of Arizona and assistant agricultural engineer in the Arizona Agricultural Experiment Station. *(Continued on page 530)*

Personals of A.S.A.E. Members

(Continued from page 528)

John R. Haswell, in charge of agricultural engineering extension, Pennsylvania State College, is author of a discussion of the need of considering soil characteristics in determining the site and in planning drainage of air fields, including the efficient use of trenching machines in ditching for such work and laying the tile to provide the greatest depth of drainage on runways, which discussion appears under the title "Military Air Fields: a Symposium" in the A.S.C.E. Transactions for 1945, vol. 110, pp. 796-7.

Milton T. Hedquist recently entered the employ of the John Deere Harvester Works of Deere & Co., at East Moline, as a design engineer. He was previously employed as implement designing supervisor of J. I. Case Company at Rock Island, Ill.

Max C. Jensen, formerly civil engineering specialist of the U. S. Soil Conservation Service at Caldwell, Idaho, has resigned to accept a position as associate professor of agricultural engineering at the University of Idaho and as irrigationist in the Idaho Agricultural Experiment Station.

M. R. Lewis, irrigation engineer, U. S. Reclamation Service, discusses "Sprinkler Systems—Pro and Con," in a short article in the October issue of "The Reclamation Era."

Oscar H. Lowery, who served as a lieutenant in the U. S. Naval Reserves during the war, being stationed at the Naval Air Technical Training Center at Gainesville, Ga., has recently joined the agricultural engineering staff of Purdue University.

Samuel T. Moore, Jr., who served as a lieutenant in the U. S. Army Air Forces during the war, is now assistant teacher of vocational agriculture at South Hill High School at South Hill, Virginia, where he is teaching a class of veterans in on-the-job-training in agriculture.

Ira L. Williams, who for the past four years has been serving as district engineer of the U.S. Soil Conservation Service in West Texas, recently resigned to accept appointment as a member of the agricultural engineering teaching staff at Louisiana State University. His specialty will be training engineers for soil conservation work.

New Literature

LITERATURE SEARCH ON THE PRESERVATION OF FOOD BY FREEZING, by B. H. Weil and Frances Sterne. Paper, 5½x8½ inches, VII + 409 pages. Indexed. Special Report No. 23, State Engineering Experiment Station, Georgia School of Technology, Atlanta, $4.00. An annotated bibliography of 2095 published items in this field, to early 1946, including U. S. and foreign patents. Literature abstracts are in alphabetical order of authors names, and patents in order of patent numbers. The index is by subjects, including foods, processes, equipment, and related sciences. Source material included Chemical Abstracts, Biological Abstracts, the Engineering Index, and the Industrial Arts Index. The Tennessee Valley Authority was a joint sponsor with the publisher on this project.

REPORT ON RURAL ELECTRIFICATION. Paper, 114 pages, 8½x11 inches. Government Publications Sales Office, 3-4, College Street, Dublin, Eire, 5 shillings. Rural electrification in Eire (Ireland) summarized by the Electricity Supply Board in terms of design, construction, capital estimates; review of development in other countries; organization management, and service; and financial aspect and rates of charge. More than half the book is devoted to appendices including tables, graphs, and illustrations.

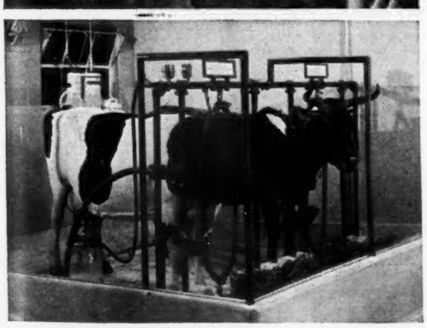
"FARM BUILDINGS," by John C. Wooley. Second edition. Cloth, VIII + 354 pages, 5½x8½ inches. Illustrated. Indexed. McGraw-Hill, $4.00. A text and reference with chapters set up as units for study, and with emphasis on grouping of facts, together with other aids to help the student develop correct conclusions. Chapters are grouped into parts covering general matters, livestock and poultry buildings, air-conditioning farm buildings, building materials, structural design, buildings for storage, the farm home, and drafting. An appendix gives 16 suggested laboratory exercises. A list of visual aids to teaching of the subject is included.

SIXTY-BUSHEL SWEET POTATO STORAGE ELECTRICALLY HEATED by J. W. Simons and W. E. Hudson. (Agricultural Engineering Department, University of Georgia.) This will be of interest not only from the standpoint of its subject matter, but as Vol. 1, No. 1, of a series of bulletins. It is printed on both sides of a single 8½x11-inch sheet of paper and folded to 3¾x8½ inches for low-cost 3rd-class mailing without envelope. One side includes the title, some construction do's and don'ts, operation hints, and address space. The other side shows floor plan, section and perspective views, door detail, wiring diagram, and bill of materials.

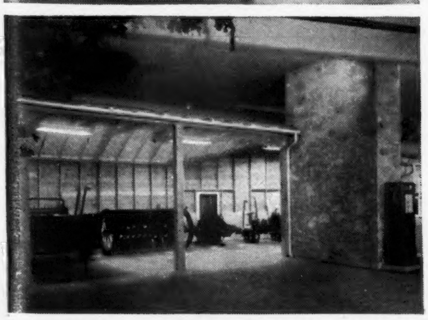
(Continued on page 532)

SEE "Harvester Farm"

Contour plowing for better land use is included among the many approved farm practices portrayed at "Harvester Farm." Remember, your land is your security...keep that precious layer of topsoil.



The champion Holstein, fully animated, breathes, and is milked by an International Harvester milker. Construction of the five cows required the skillful craftsmanship of a master taxidermist.



Good farmers everywhere take pride in caring for their equipment... Here, the machine shed protects such IH products as the grain drill, hammer mill and spreader. In the fields are a Farmall tractor, plow, self-propelled combine, and pick-up baler.

Write Museum of Science and Industry, Chicago 37, Ill., for illustrated booklet describing "Harvester Farm"

THE NEXT TIME YOU'RE IN CHICAGO AT MUSEUM OF SCIENCE AND INDUSTRY IN JACKSON PARK

THAT COMPLETELY MODERN, mechanized farm you've always wanted to inspect at close range is now on year-round view in Chicago... *indoors,* where the summer sun shines every day! It's "Harvester Farm," constructed by International Harvester as a permanent exhibit of the Museum of Science and Industry.

There's inspiration for farm wives inside the charming Colonial farmhouse. Designed from the expressed preferences of farm families throughout the country, this house has a neat, efficient kitchen with every modern convenience, including the latest type of home refrigeration.

At the end of the walk is the big white barn that houses the five most productive breeds of dairy cattle. In the spic-and-span milk house every milk-handling operation is done with sanitary, labor-saving equipment. Other farm buildings — workshop, brooder house, forge, etc. — are found on "Harvester Farm" just the way you'd like them on your place.

These are only the high points of this exhibit, in which the farm fields seem to stretch to the far horizon. Plan to see it—57th Street, Jackson Park—when visiting Chicago.

INTERNATIONAL HARVESTER COMPANY
180 North Michigan Avenue Chicago 1, Illinois

INTERNATIONAL HARVESTER

New Literature *(Continued)*

A Surface Water Treatment System for the Rural Home, by Joe B. Winston. (Paper, 42 pages, 6x9 inches, illustrated. Bulletin No. 89, 1945, Texas Engineering Experiment Station, A. & M. College of Texas.) Construction, installation, operation, and maintenance details on a satisfactory system.

How Research Creates New Markets for Hardwoods (Paper, 16 pages, 6x9 inches, illustrated. Timber Engineering Co., Washington 6, D. C.) A brief explanation and examples of research service available to processors and users of hardwoods.

Soil Tests for Military Construction by Major George E. Bertram, CE (Paper, 96 pages, 6x9 inches, illustrated, and indexed. Technical Bulletin No. 107, 1946, American Road Builders Assn., 1319 F St., N.W., Washington 4, D. C. 50 cents). Deals with field identification of soils, equipment, laboratory setup, soil exploration and sampling and test procedures, with particular reference to soils as foundations for roads and airport runways carrying heavy traffic.

"Dimensioning and Shop Processes," by J. G. McGuire. Paper, 60 pages, 6x9 inches. Bulletin No. 88, Engineering Experiment Station A. & M. College of Texas. A supplementary test and reference prepared as an aid to beginning students in engineering drafting who have not yet had courses in shop processes. It presents a philosophy and background for the rules and procedure of dimensioning to help the student understand some of the requirements of engineering drafting. Chapters cover the pattern shop and the drawing. the foundry and the drawing, the forge shop and the drawing, and the machine shop and the drawing.

Adobe as a Construction Material in Texas, by Edwin L. Harrington (Paper, 35 pages, 6x9 inches, illustrated. Bulletin No. 90, 1945, Texas Engineering Experiment Station, A. & M. College of Texas.) Includes a historical sketch of adobe as a building material, survey of adobe construction in Texas, and instructions on selecting the soil and on construction procedure.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Donald S. Barry, Jr., design engineer, Howard Green Co., Cedar Rapids, Iowa. (Mail) 1860 First Ave., S.E.

Keith H. Beauchamp, drainage engineer, Soil Conservation Service, USDA. (Mail) 4650 N. Port Washington Road, Milwaukee 12, Wis.

Frank J. Capouch, director, field service dept., Bowman Dairy Co. (Mail) 300 N. East Ave., Oak Park, Ill.

William A. Dennin, architect, farm structures and rural housing division, (BPISAE), U. S. Department of Agriculture. (Mail) 39 Cedar Lane, "Sleepy Hollow", Falls Church, Va.

C. G. Fisher, manager, Northside Lumber & Coal Co., 502 E. Marion St., Mishawaka, Ind.

Warren E. Garner, research assistant in agricultural engineering, University of Georgia, Athens, Ga.

Harry P. Hadler, advertising editor, International Harvester Co., 180 N. Michigan Ave., Chicago, Ill.

Paul L. Hamman, farm industry specialist, General Electric Company. (Mail) 4966 Woodland Ave., Cleveland 4, Ohio.

Roland C. Heath, general sales manager, Tullos, Ltd., Aberdeen, Scotland.

Walter R. House, power engineer (agricultural and rural power sales), Gulf States Utilities Co., Lake Charles, La.

Percy F. Kiffe, northwest district representative, tillage and seeding machines, International Harvester Co. (Mail) 1[illegible] E. Cherry St., Mankato, Minn.

Ortie LaVoy, architectural engineer, Weyerhaeuser Sales Co., First National Bank Bldg., St. Paul, Minn.

Roy K. Lagow, agricultural engineer, Soil Conservation Service, USDA. (Mail) 6th floor, Records Bldg., Dallas, Tex.

Candler C. Miller, cotton ginning specialist, Georgia Agricultural Extension Service, Athens, Ga.

Frank L. Myers, manager of farm program, Owens-Corning Fiberglas Corp., Toledo, Ohio. (Mail) 2853 Inwood Drive.

M. K. Nandi, graduate student in agricultural engineering, University of Minnesota, University Farm, St. Paul 1, Minn.

Francisco M. Parama, research engineer, Comision Nacional de Irrigation, Mexico, D.F. (Mail) Matolinia 2, Despache 42.

Thomas M. Reed, assistant sales promotion manager, Phillips Petroleum Co., Bartlesville, Okla. *(Continued on page 534)*

Album of American Agriculture

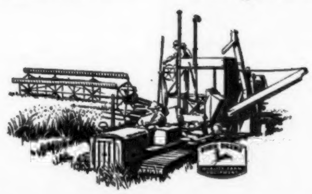
GRANDADDY OF THE MODERN COMBINE

SPIT curls and bustles were the rage in 1886, when Benjamin Holt created the grandaddy of the modern John Deere No. 36 Combine. His machine was a cumbersome rig, pulled by twenty head of mules and operated by a big crew of men, but it ushered in a new and more profitable era in grain farming.

During the Gay Nineties, Holt continued to improve his combine. By the turn of the century his giant combines dotted Pacific Coast wheatfields at harvest time. Combine harvesting had won widespread acceptance in the West.

With the purchase of this line of hillside and large, level-land combines, in 1935, John Deere fell heir to half a century of combine manufacturing experience, as well as a field-proved design that incorporated an imposing array of exclusive, patented features.

Modern John Deere No. 36 Hillside and Level-Land Combines, even better than their famous predecessors, are the harvest queens of the Pacific Northwest, the Dakotas, and the Canadian plains. Today, there's a grain-saving John Deere Combine in the size and type to match the needs of every grain and seed grower all over America.



JOHN DEERE QUALITY FARM EQUIPMENT SINCE 1837

PROFESSIONAL DIRECTORY

Applicants for Membership

(Continued from page 532)

George W. Schroeder, service manager, Iowa Tractor & Implement Co., 1300 Walnut St., Des Moines, Iowa.

Luther S. Singley, rural service representative, West Penn Power Co. (Mail) Monessen, Pa.

Frank E. Torrance, assistant chief engineer, Donaldson Co., Inc. (Mail) 3136 1st Ave., S., Minneapolis, Minn.

Willie E. Westbrook, instrumentman, State Highway Department of Georgia, La Fayette, Ga. (Mail) 36 North Main.

W. Ted Williams, estimator, Northside Lumber & Coal Co., 502 E. Marion St., Mishawaka, Ind.

TRANSFER OF GRADE

Angus Banting, provincial agricultural engineer, Nova Scotia Department of Agriculture, and professor of agricultural engineering, Nova Scotia Agricultural College, Truro, N.S., Canada. (Junior Member to Member)

Clarence J. Bush, utility specialist (irrigation), Rural Electrification Administration, USDA. (Mail) 308 S. Union St., Dwight, Ill. (Junior Member to Member)

M. Hamilton Clark, executive vice-president, Foster Machinery Co., P. O. Box 863, Albany, Ga. (Junior Member to Member)

George W. Endicott, manager, rural electrification, Southern Illinois Electric Coop., Dongola, Ill. (Junior Member to Member)

Clarence A. Frese, designing engineer, Hardie Manufacturing Co., Hudson, Mich. (Junior Member to Member)

William J. Gillespie, Jr., rural supervisor, Appalachian Electric Power Co., Plaski, Va. (Junior Member to Member)

H. S. Glenn, manager, Colquitt County Rural Electric Co., P. O. Box 392, Moultrie, Ga. (Junior Member to Member)

Jack A. Griffin, agricultural engineer, Soil Conservation Service, USDA. (Mail) Box 983, Marfa, Tex. (Junior Member to Member)

R. C. Hines, Jr., assistant agricultural engineer (extension), Virginia Polytechnic Institute, Blacksburg, Va. (Mail) P. O. Box 458. (Junior Member to Member)

Earl M. Lewis, rural electrification specialist, Southwestern Public Service Co., Plainview, Tex. (Junior Member to Member)

Erling J. Nossum, county agent at large, North Dakota Agricultural Extension Service. (Mail) Milnor, N. D. (Junior Member to Member)

Mathew M. Novak, engineer, Harry Ferguson, Inc., 15020 Woodward Ave., Detroit 3, Mich. (Junior Member to Member)

Oscar C. Rice, Jr., service manager, O. C. Rice & Son, Biglerville, Pa. (Junior Member to Member)

Lawrence O. Russell, assistant branch manager, J. I. Case Co. (Mail) 4260 Forest Park, St. Louis, Mo. (Junior Member to Member)

William C. Wheeler, associate professor of agricultural engineering, University of Tennessee, Knoxville, Tenn. (Junior Member to Member)

J. R. W. Young, acting head, department of agricultural engineering, University of British Columbia, Vancouver, B. C., Canada. (Junior Member to Member)

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration or license as a professional engineer.

NOTE: In this Bulletin the following listings still current and previously reported are not repeated in detail. For further information see the issue of AGRICULTURAL ENGINEERING indicated.

Attention is invited to the desirability of checking on the housing situation when considering a new location.

POSITIONS OPEN: FEBRUARY—O-448. MAY—O-499, 500, 502, 503. JUNE—D-504, 506. AUGUST—O-510, 511. SEPTEMBER—O-516, 520, 521.

POSITIONS WANTED: FEBRUARY—W-207, 210, 211, 234, 248, 254. APRIL—W-232, 237, 240, 258, 262, 276, 292. MAY—W-309, 312, 313. JUNE—W-316, 319, 320, 321, 322. JULY—W-327, 328. SEPTEMBER—W-334, 336, 337, 339, 341, 346. OCTOBER—W-348, 349, 351, 352, 353.

POSITIONS OPEN

AGRICULTURAL ENGINEER wanted by the Allahabad Agricultural Institute, Allahabad, India, for teaching position. Minimum qualifications, degree in agricultural engineering and some farm experience. Postgraduate desirable. Duties would be primarily teaching, with some opportunity to participate in research and extension. Candidate must be active Christian interested in mission work. Discharged veteran with slight handicap eligible if in good health otherwise. Applicants may correspond with Allahabad Agricultural Institute. Attention of Dr. Herrick B. Young, Secretary, 156 Fifth Ave., New York 10, N. Y.

AGRICULTURAL ENGINEER (junior, intermediate, or senior instructor rank) for teaching agricultural engineering and agricultural mechanics in a state polytechnic school in the Southwest. MS or Ph D degree in agricultural engineering, or equivalent, and some research, teaching or commercial experience in the field preferred. Age 25-45. Salary $3384 min. to start. O-523

AGRICULTURAL ENGINEER (instructor or assistant professor rank) for teaching and research, primarily in farm machinery in southeastern state college. BS or MS degree in agricultural engineering, or equivalent, and some previous experience in the field preferred. Salary $2700-$3120 to start. O-524

ASSISTANT RESEARCH AGRICULTURAL ENGINEER for work on rice and other small grain production, drying, and processing equipment in south central state university. BS deg in agricultural engineering required, MS deg highly desirable. Man raised on farm or with some farm experience preferred. Employment on 12-month basis with 30 days annual leave. Age 23-30. Salary $2700 - $3100 to start, depending on education and experience. O-525

POSITIONS WANTED

AGRICULTURAL ENGINEER desires field research, sales or service work in farm power and machinery or rural electrification work. BSA degree, with major in engineering, North Dakota Agricultural College, 1940. Experience in farming, 2 years; Army Ordnance inspection 11 months; Army enlisted and commissioned, over 3 years. No physical defects. Available on short notice. Married. Age 27. Salary $3000 min. W-354

AGRICULTURAL ENGINEER desires design, development, research, or sales work in farm structures field. BSAE degree. Virginia Polytechnic Institute, 1940. Experience since graduation, 6 years as draftsman with shipbuilding and drydock company. No physical defects. Available Jan. 1, 1947. Married. Age 29. Salary $2700-$3500. W-355

AGRICULTURAL ENGINEER desires product processing or development work in private industry, or extension work in public service. BSAE degree, University of Georgia 1944. Experience as assistant manager and engineer in university creamery before graduation; Navy 10 months enlisted and commissioned service, and instrument man for state highway department on location and construction, one year. No physical defects. Available Jan. 1, 1947. Married. Age 25. Salary $2400 min. W-356

AGRICULTURAL ENGINEER desires development or sales work in field of irrigation and related equipment, with emphasis on soil and fertility conservation. BS deg in forestry, Michigan State College, 1940. Currently engaged in graduate study in soils and irrigation. Experience 2½ years in heavy construction, with steel, and 2½ years in Navy. Temporarily partial disability due to war service limits amount of walking and similar physical work that can be done. Available Feb. 1947. Single. Age 28. Salary $2500. W-358.

AGRICULTURAL ENGINEER desires rural electrification work, in service or sales. BS deg in agricultural engineering expected Jan. 1947, A &M College of Texas, Experience 4 months as seismograph surveyor, 1942; U. S. Navy 16 months. No physical defects. Available February 1, 1947. Single. Age 21. Salary Open. W-359.